Information Required From Planning Yards To Support Zone Logic

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FINAL REPORT

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INFORMATION REQUIRED FROM PLANNING YARDS TO SUPPORT ZONE LOGIC

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For
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Design/Production Integration Panel Sp-4

Under The
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In Cooperation With
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EXECUTIVE SUMMARY

Recommendations in six categories have resulted from this study . They are to:

- o Improve the manufacturing system
- o Develop generic strategies per ship class
- o Institute zone oriented design stages
- o Establish production engineering in planning yards
- o Shift to product oriented material management
- o Recognize planning yard activities as part of the manufacturing system and revise and update the Fleet Modernization Program Management and Operations Manual accordingly.

More detail discussion of these recommendations follows.

1. IMPROVE THE MANUFACTURING SYSTEM

There is great need for OpNav and NavSea to recognize that a shipyard's ability to improve itself while implementing ShipAlt work is just as much a military requirement as upgrading weapons systems in warships. Fortunately’ virtually all military and technical improvements can be achieved while simultaneously and manifestly providing for manufacturing system improvement.

OpNav should state, "A shipyard's ability to improve its manufacturing system during implementation of any work is a military requirement."

NavSea should state in The Fleet Modernization Program Management and Operations Manual, "Shipyards shall provide for improvements in their manufacturing systems during ShipAlt implementation."

Significant improvement is dependent upon concerted application of all of the basic management functions, that is:

- ° estimating,
- ° planning (design is an aspect of planning),
- ° scheduling,
- ° implementing (both material marshaling and producing), and

° evaluating.

Therefore, with particular emphasis on those who participate in developing contract requirements, a manufacturing system must be regarded as including all organizations influence how shipyards perform. For ShipAlt work they include:

- Ship Logistics Managers(SLMs)/Program Managers (PMs),
- Type Commanders (TyComs),
- Engineering Directorates (EDs), and
- planning yards.

SLMs, PMs, TyComs, and EDs are customers. They should understand that their best interests are served when their military and technical requirements are formatted in a way that permits further refinement and eventual implementation per modern, zone oriented manufacturing technology.

Planning yards serve two masters. They function as agents of customers during their preparation of:

- ShipAlt Records, that is, preliminary design activities that are sufficient for ShipAlt programming decisions, and
- SIDs that have the effect of contract drawings.

And they serve implementing shipyards during their preparation of such other SIDs that are required.

OpNav should state, "Because contract design is part of the manufacturing system, SLMs/PMs, TyComs, and EDS, shall negotiate, preferably with implementing yards, but otherwise with planning yards acting as surrogates, for the purpose of incorporating effective implementation strategies in contract drawings."

2. DEVELOP GENERIC STRATEGIES PER SHIP CLASS

Zone/stage control of work combined with addressing each type of work separately (for example, light-fitting rip out and heavy-fitting rip out), are all that are needed to devise a very useful, generic alteration strategy by ship class. That part of a strategy that applies to a single specialty within one ship class, say for machinery spaces, since it is by type of work, will be similar to that required for another ship class. Thus, very much can be adapted from class to class by just taking into account the different compartmentation.

OpNav should authorize a special project for the purpose of developing generic strategies that planning yards should use to preview how zone oriented work is most likely to be implemented.

NavSea should direct planning yards to provide codes in their design models so that they can offer implementing yards a choice of information in zone/stage groups that match a generic strategy or in traditional system-by-system groups.

3. INSTITUTE ZONE ORIENTED DESIGN STAGES

Contract and functional design are distinct stages in a traditional design approach. Transition and work instruction design stages do not exist. Zone orientation features system-by-system expertise applied to functional matters and initial material definition, but it also relies on zone oriented expertise per regional specialty, particularly for detail design and exact material definition. As more than two thirds of design man-hours are spent on detail design, the corporate culture will change for the majority involved in ShipAlt design efforts.

The change will entail a culture shock for many who believe they have achieved security by commanding design aspects of a particular function. Their vision cannot be expected to include optimizing implementation of entire ShipAlts nor their roles as de facto participants in a manufacturing system which has the obligation to continually improve.

NavSea should provide special assistance to planning yards in the form of programs to indoctrinate designers in zone logic, to identify people who cannot make the transformation, and to provide such people with other work or early retirement.

NavSea should require planning yards to implement the four distinct zone logic design stages, including, contract, functional, transition, and work instruction.

4. ESTABLISH PRODUCTION ENGINEERING IN PLANNING YARDS

Although a generic strategy per a ship type would be available, each planning yard would still require its own production engineers. They would be required at first to adjust a generic strategy in the context of a particular set of ShipAlts authorized for simultaneous implementation. Until an implementing yard is designated, planning yard production engineers would have to refine their strategy as design progress makes more information available.

NavSea should require each planning yard to develop a production engineering capability for each specialty represented in the ship classes assigned to them. Each person so assigned should have keen understanding of ship operational, ship maintenance, and shipyard manufacturing system matters for the specialty assigned.

5. SHIFT TO PRODUCT ORIENTED MATERIAL WAGEMENT

Since material is the only tangible, the most effective shipyard management systems control production through control of material. Consumed man-hours are reported per physical characteristic of the interim products completed and according to the problems they impose, for example, man-hours: per length of electric-cable pulled separately for large, medium and small diameters; per pipe pieces fabricated separately by pipe-piece family; and per weight of electronic work packages separately for shop assembly and for on board assembly.

Statistical analyses of man-hour cost returns identify how such work normally (mean values and standard deviations) performs and are the bases for man-hour budgeting and scheduling. When constant comparisons by computer disclose material types or volumes defined during any design stage that exceed those in the contract design material budget, budgeted man-hours increase accordingly and schedules have to be confirmed or adjusted. In order to maintain the validity of the material/man-hour corporate data, certain material management techniques are required.

Since they influence material/man-hour relationships, certain U.S. Navy purchasing activities, and material suppliers including those for Centrally Provided Material (CFM) are also de facto parts of a yard's manufacturing system. In other words both material and production responsibilities are operational matters that should respond to the same ship modernization strategy. Further, the productivity of a manufacturing system is dependent upon knowing beforehand how material suppliers will perform as well as how their products will perform. Therefore operational considerations should be the primary basis for procurement regulations that shipyards must follow.

OpNav should, except for CPM and LLTM necessarily ordered before an implementing yard is designated, transfer all remaining material procurement responsibilities to implementing yards. This recommendation is peculiar to naval shipyards because they are required to employ purchasing activities outside of their commands for a significant part of their material procurement activities.

NavSea should work to remove any restrictions that may exist that prevent shipyards from initially ordering certain materials from diagrammatic, and from limiting the number of eligible bidders for productivity reasons. Large amounts of corporate data are essential for a modern manufacturing system. Regarding each product, this includes design details, approval status, quality, accuracy, ILS, prices, scheduled delivery record, and guarantee service record. Attempting to build the needed file of corporate data without limiting the number of prospective bidders for each item to no more than three, is simply impractical.

NavSea should require naval shipyards, and should recommend to private shipyards, that they employ the allocated stock (AS) material management concept.

NavSea should require naval shipyards, and should recommend to private shipyards, that they relate materials to man-hours.

NavSea should require naval shipyards, and should recommend to private shipyards, that they employ a computer to constantly compare materials being defined in later design stages to material budgets developed during contract design.

6. GENERAL

NavSea, as well as all those involved in the construction, modernization, overhaul and repair of naval ships, have a critical need to reexamine the way in which information, people, material and work are organized. Although the benefits of exploiting zone technology in production work are generally recognized, the rest of the manufacturing system has not been evaluated and altered to suit this approach. In general, most participants in the manufacturing system continue to employ system-by-system thinking for all preparations leading to production. Just before production starts, attempts are then made to reorganize information to utilize zone technology in production. Logically, one strategy is employed until production work is to start, and then a switch to a completely different one is made. This situation is the result of a manufacturing system that has evolved over many years.

This publication sets forth the premise that all parts of the ship odernization, overhaul and repair process should be recognized as being part of one manufacturing system. Thus the activities of planning yards are a critical part of the manufacturing system. Further, specific guidance for how planning yards should go about preparing ShipAlt information in order to facilitate implementation of zone logic is provided. OpNav and NavSea should review, evaluate and act upon these recommendations as a means of improving it's ability to manage the construction, modernization, overhaul and repair of the naval fleet. As a practical matter, NavSea should revise and update the FMP Manual to reflect the goal of supporting and encouraging the productivity gains that can be achieved by employing zone logic in ship repair, overhaul and modernization programs. Suggestions for many of the revisions are provided in Part 3 of this report.

PREFACE

The authors of this report are Dr. Richard L. Storch, Industrial Engineering Program, University of Washington and Mr. Louis D. Chirillo, Bellevue, Wa. The research was conducted for the National Shipbuilding Research Program and Newport News Shipbuilding, the program manager for Panel Sp-4 (Design Production Integration) of the Society of Naval Architects and Marine Engineers Ship Production Committee. Program managers for Newport News Shipbuilding were Mr. R.K. Neilson, initially and Mr. W.G. Becker.

The goal of this project is to provide guidance to planning yards concerning specific changes that should be incorporated in the type of information that they provide to facilitate the adoption of zone logic technology in ship modernization, overhaul and repair. In order to achieve this goal, the researchers combined insights into zone logic applications in new construction, literature review and analysis in ship production, ship repair, and modern manufacturing technology. A series of visits and discussions with people involved in all aspects of naval ship work, was also a part of the data gathering effort.

The data gathering visits were to people involved in planning yard and implementing activities at Puget Sound Naval Shipyard, Philadelphia Naval Shipyard and Norfolk Naval Shipyard. Additionally, people involved in planning yard activities at Newport News Shipbuilding were also visited. Other implementing yards visited included The Jonathan Corporation and Metro Machine, both in Norfolk. Also, discussions were held with representatives of NavSea 0721 concerning their Advanced Industrial Management program.

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1.0 INTRODUCTION

1.1 BACKGROUND

The U.S. Navy's Fleet Modernization Program "was established to provide a structure for the orderly planning, programming, budgeting, and installation of military and technical improvements to ships . . . . " The process may be said to start with a sponsor's description of an idea for improvement, ". . . including its purpose, and its relationship to existing equipment systems." When approved, in the context of operational requirements for proposed military improvements and in the context of safety, reliability, maintainability, and efficiency for proposed technical improvements, an idea is systematically processed for further study. Dependent on the nature of a proposed improvement, an appreciable investment may be made in order to ".. .measure the degree of increase in the ship's capability to perform its mission and. .."[1] the estimated "...cost for materials, installation, and design resources needed to carry out the proposed improvement."[1]

Each idea for which approval is sustained then becomes the subject of a Ship Alteration Proposal (ShipAlt Proposal or SAP), "...a baseline document which consolidates known technical and materials information . . . ." A unique number is assigned for tracking purposes, applicable hulls are identified, and the ShipAlt Proposal is entered into the Navy's Amalgamated Military and Technical Improvement Plan.

Next, each ShipAlt Proposal is usually assigned to a planning yard for preparation of a Ship Alteration Record (ShipAlt Record or SAR). A planning yard is specialized by ship class and may not necessarily be one of the yards designated for the production phase. In the process of preparing a ShipAlt Record, a planning yard ". . .updates and documents the complete technical requirements and specifications that define the alteration. This information forms the basis for ShipAlt installation design efforts and provides data on which ShipAlt programming decisions should be made." Thus the earliest planning yard activity is part of Estimating, one of the five major functions for any industrial management cycle as shown in Figure 1-1. As a

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1 All quotations unless otherw ise noted are from the U.S. Navy's Fleet Modernization Program Management and Operations Manual, SL720-AA-MAN-010, January 1985 with Change 7, November 1988.

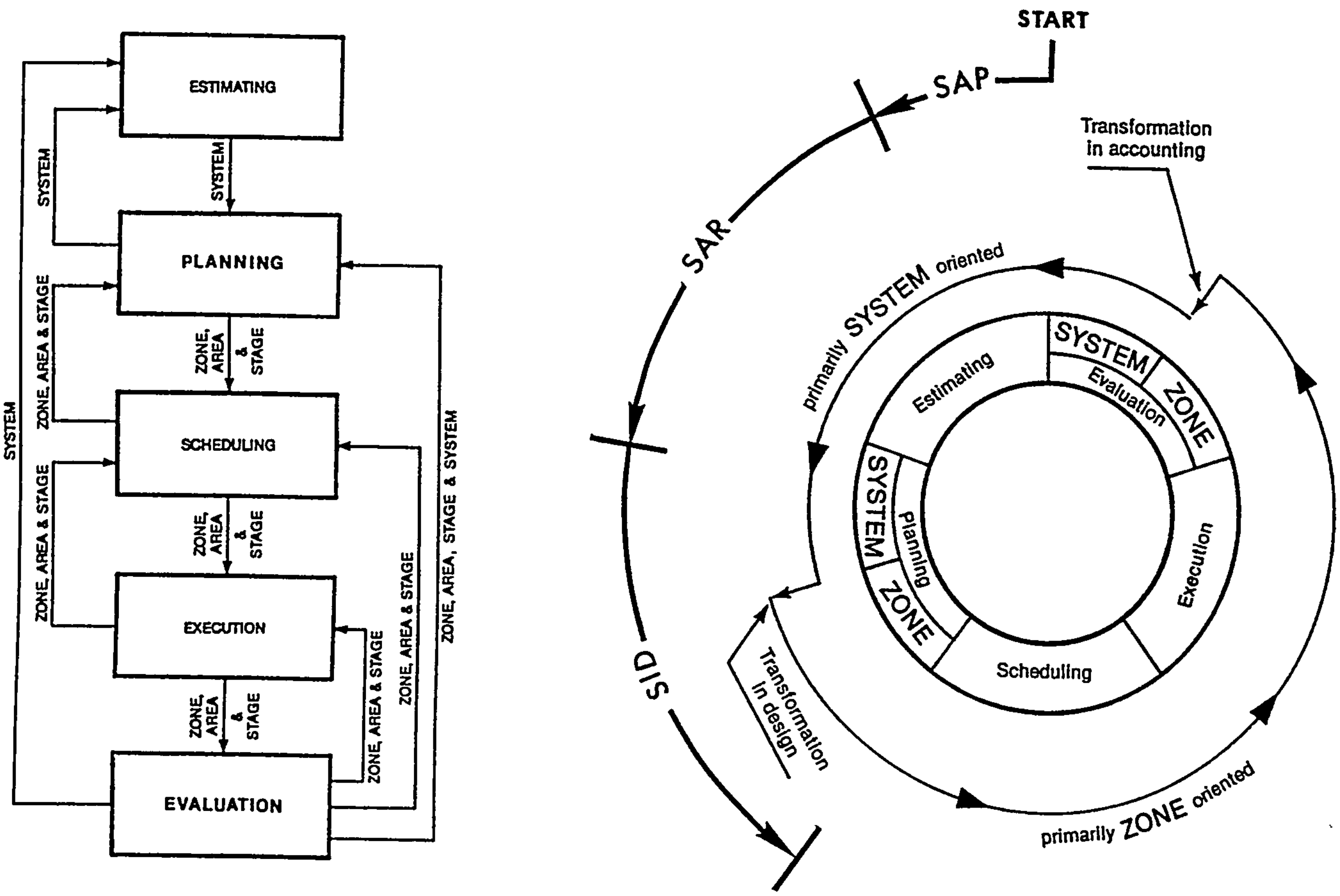

FIGURE 1-1: Two views of the management cycle for a zone oriented approach to any heavy industrial process, including ship construction, modernization, overhaul, and repair. Planning includes design and material defintion. Execution includes material procurement and production.

practical matter, estimating is almost always performed by system. The process is the same as that employed by commercial-ship operators when they consult with their own technical staffs, or design subcontractors, during preliminary design activities for ship modernization.

Thereafter ShipAlt programming decisions involve many organizations and require a relatively complex reiterative process for budgeting, budget review and adjustment, and/or reassessment of requirements. During the reiterations, methods for implementing each ShipAlt are addressed. This represents the start of Planning in the management cycle. Special note is made that design and material definition are aspects of planning. Hereafter, usage of just the word planning implies that design is included.[2]

Ideally, the reiterative process leading to a list of ShipAlts approved for installation would include customer/planning yard/implementing yard negotiations. The negotiations would be aimed at identifying the information produced in basic design that should be used as contract design documents for a specific number of ShipAlts to be implemented simultaneously. The implementing yard's production engineers, as participants in the negotiations, would contribute the most cost-effective implementation strategy, consistent with achieving each ShipAlt's functional objectives, before the major expenditure of design man-hours.[3]

The arrangements shown on contract drawings, would then reflect production engineering for various productivity objectives, such as:

- combining foundations, even for different ShipAlt equipment,
- delineating separate outfit packages, regardless of different Shipalts represented, that will be assembled in shops and the sequence for their installation on board,
- maintaining distributive systems in parallel runs

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2 "Expanded Planning Yard Concept and Configuration Accounting, or Improving Navy Ship Engineering," by A.R. Karn and E. Runnerstrom, Journal of Ship Production, November, 1986, pp. 238-244.

3 Customer as used herein designates any U.S. Navy organization having approval authority.

that are as straight as possible, regardless of systems represented,

- o rip-out, redesign and reinstallation of otherwise unaffected nearby systems when such work would obviously reduce ShipAlt implementation costs, and

- o providing sequenced zones per stages by type of work so that work of one type, heavy welding for instance, may be done at the same time for all systems within a zone.

In the absence of such guidance, planning yards insufficiently integrate ShipAlts and have little or, no concern for probable overhaul work that could also be implemented simultaneously. Nor do traditional planning yards sufficiently anticipate the sequence of production activities. In other words, planning yards do not usually make transformations from system to zone orientation during the planning function (see Figure l-l), as needed to facilitate the more effective zonal approach that has been gaining acceptance in U.S. private shipyards since *1979* and in naval shipyards since *1982.*[4]

In order to support the pursuit of productivity improvement through the application of zone logic, planning yards should effect certain changes in the following drawing preparation and material definition areas:

- o ShipAlt Installation Drawings (SIDs) - These include drawings for system diagrammatic, key arrangements,

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[4]Two notable exceptions resulted from Puget Sound Naval Shipyard knowing when performing as the planning yard that it would be the implementing yard and having some key people in both design and production who understood zone logic. One exception was the extensive electronics modernization involving at least five ShipAlts in the front end of SSN-637 class submarines. "On-board [foundation] work was reduced from seven weeks to three workdays...,’, from “Increasing Efficiency Through Outfit Planning," by C. M. Murphy, Journal of Ship Production, February 1989, pp. 1-9. The second exception was for the installation of a Naval Tactical Data System/Anti-Submarine Warfare Module in USS NIMITZ (CVN-68) which took 7 months with zone logic whereas previous similar work by traditionally performing yards required 14 months. The work required ‘I . ..nearly 30 miles of new cabling, 250 foundations, new furniture of all types and hundreds of feet of both ventilation ducting and piping...”, from "CIC Upgrade on NIMITZ Nears Completion,” Salute, Puget Sound Naval Shipyard, 19 April 1990, pp. 8-9.

temporary access/egress, temporary shoring, rip-out, structure, arrangements, manufacturing, assembly and details, electrical diagrams, and cabling sheets as needed by an implementing yard. SID's are comprehensive and exclude only the final drawings commensurate with final planning stages which are usually produced by implementing yards. SIDs may include integrated designs to " ..represent work required by two or more ShipAlts, usually to be accomplished in the same space or area of the ship . . . ." at the same time. "Completion of SIDs is to be accomplished no later than 12 months before start of scheduled availabilities (A-12)."

- Centrally Provided Material (CPM) - These are first defined in ShipAlt development documents, such as ShipAlt Records, and are designated for numerous reasons to be centrally procured and delivered to implementing yards as Government-furnished material. Specific dispositions of CPM are included in Bills of Material (BOMs) that accompany SIDs.

- Locally Provided Material (LPM) - These are items that are listed in BOMs that accompany SIDs and that are designated for material management (procurement and control) by implementing yards.

- Long Lead Time Material (LLTM) - This is another way of classifying materials as LLTM applies to both CPM and LPM.[5]

The needed changes require that more production engineering be applied in planning yards before implementing yards are designated.

1.2 UNDERSTANDING TRADITIONAL "PLANNING" AND SCHEDULING

Traditional specifications for the modernization of naval ships and submarines are written to describe what is to be done (remove, modify, relocate, and/or install) separately by system. With some exceptions, a design process is implemented for each ShipAlt only with regard for functional requirements and the need to avoid interferences. A strategy for performing ShipAlt work with regard for other work in

[5] Nothing pertaining to Integrated Logistic Support (ILS) is included because ILS procedures remain relatively unaffected by the shift from system to zone orientation. But zone logic, more than any alternate approach, forces the updating of design models to reflect true as-built arrangements. ILS is facilitated accordingly.

the same region is not usually given to designers eforehand.

In the absence of a work strategy designers assigned responsibility for a particular hipAlt usually describe required modifications or new features on system arrangement and detail drawings and provide material lists by system. The combining of ShipAlts for simultaneous implementation is done only on an exception basis. Design is not implemented as an aspect of planning. Planning takes place afterwards as shown in Figure 1-2.

In each naval shipyard, the system-by-system design output is passed to “planners” and estimators who, while part of the “planning” department, have no responsibility for initial planning, that is, an overall production-engineered strategy. Upon receipt of drawings, they simply allocate man-hours and materials based on a work breakdown by systems, subdivided by line items (such as remove or install a large valve) , which are broken down by key operations incident to each line item (erect scaffolding, remove insulation, etc.) . As a rule of thumb, they try to have 90% of the key operations issued when ship modernization starts so that the senior civilian production management (group superintendents) "then know what the total modernization requirement is all about.”

It is not unusual to have as many as 8- or 9-thousand key operations, having lead- and assist-shop designations, issued for implementation by sixteen shops. They are usually published as a lot just a month or two before work is to start and a computer is used for scheduling all the key operations even though some of them may not have to be implemented within the next 10 or 12 months. Many production supervisors spend time at the very beginning of each ship availability studying a mass of data in an attempt to make sure that all support shops are scheduled to meet their priorities throughout the entire availability.

Also, scheduling a month or two before work is to start does not serve design and material procurement and marshaling people who otherwise could have sequenced their activities to exactly anticipate production needs. They too are unknowingly spending critical pre-availability time on actions that do not have to be taken for the next 10 or 12 months. The approach, while adequate but inefficient when ships were simple, is no longer appropriate due to the complex nature of modern ships. Critical planning time elapses and just before ship arrival, production supervisors are suddenly concerned with tactics without strategic guidance. The result is often a quick abandoning of the overall plan in order to show some “progress."

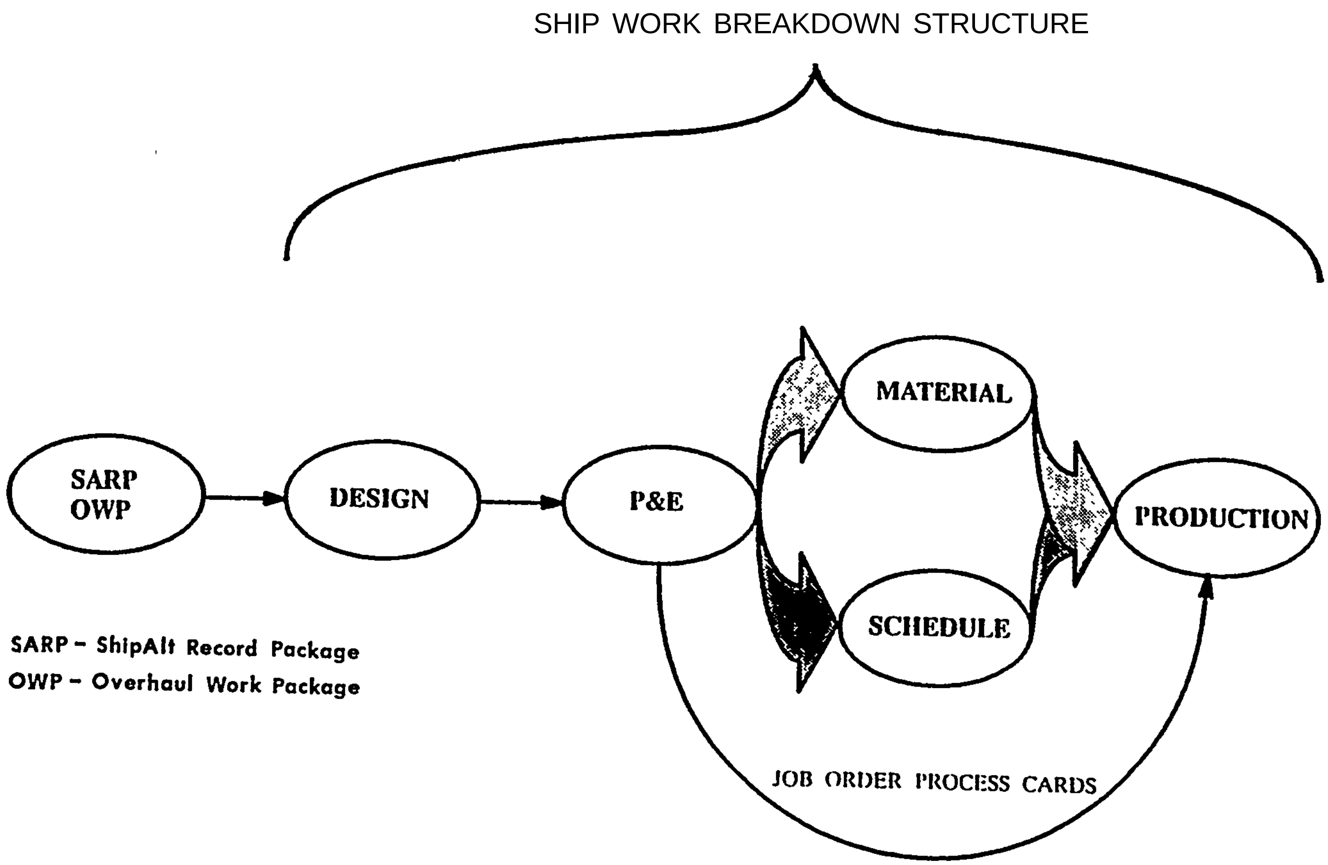

FIGURE 1-2: The traditional system approach characterized by the absence of planning before design. The application of zone logic, while possible, is very difficult. (Provided by Philadelphia Naval Shipyard)

Further, in order to develop design expertise, the Naval Sea Systems Command (NavSea) instituted the planning yard concept wherein certain public and private shipyards are each assigned design responsibilities for one or more specific ship classes. A planning yard is responsible for maintaining ship class and individual ship records, and is charged with responsibility to initiate ShipAlt design development early in the decision making process. The planning yard approach is preferred by traditional system-by-system designers because from their viewpoint it is specialization by problem category. But the planning yard concept as usually implemented does not facilitate development of any implementing yard's manufacturing system because it introduces a significant obstacle, the physical separation of ShipAlt designers from shipyard people who have the experience needed for developing effective ship-modernization strategies. [6]

The third strike, *so to* speak, comes from developing the designs of too many ShipAlts independent of each other.

1.3 UNDERSTANDING ZONE TECHNOLOGY

The term Zone *Technology* (ZoneTech) is being used within the naval shipyard community to identify product orientation, a superior way of grouping information that planning yards should routinely employ for ship modernization work. Zone/Stage Technology is a more descriptive title. There are two key definitions:

- A product work breakdown structure identifies interim products (regardless of the portions of different systems they may contain) and their relationships to each other that are necessary for defining and achieving an end product, e.g., a modernized ship.

- An interim product is a discrete element identified as an objective in a work package. It is a part, subassembly, zone, system, etc., that has been transformed by the application of work. The transformation can be manifested by physical change or by change in circumstances, e.g., change of an untested piping system to a tested system.

Commensurate with these definitions, even a compartment

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6 Manufacturing system as used herein refers to an implementing yard's organization of information, people and work that is commonly employed for ship construction, modernization and overhaul. Manufacturing system is the very essence of a corporate culture.

that has been emptied of many systems as a consequence of rip-out work, represents an interim product. A clearly discernible step has been completed toward modernizing the compartment. As other steps apply for different types of work within the same zone, e.g., welding heavy foundations, assembly of pipes, and painting, an interim product is only identified when both its zone and stage are designated.

Zone is geographical and characterized by three dimensions. Stage refers to the fourth dimension, time. Stage designates when an interim product is required relative to the need for other such interim products. Thus, zone/stage designations are means for directing different people (design, material, and production) in how to group their resources for common objectives.

1.4 PALLET CONCEPT

The word pallet is used by some in place of zone/stage. Its meaning is much more significant than the commonly employed dictionary definition: “a portable platform for handling, storing, or moving materials.” To designers a specific pallet means the data (design details, material **lists**, work procedures, test instructions, etc.) needed to produce an envisioned interim product. To material management people the same pallet means the procurement and kitting of the specific materials required. And to production people it means the specific work effort that must be applied to produce that interim product. To production engineers, pallet has all of those meanings.

As shown in Figure 1-3, a pallet serves as an information link which coordinates the efforts of people having different responsibilities, toward a common goal.[7]

1.5 PALLET LIST

In the context of the broad definition of a pallet, to palletize means to group information, material, and work as preparation for producing a series of discrete objectives (interim products). A pallet list is identification of the interim products required to complete a project. When a pallet list is presented in the sequence in which the work is expected to be performed, it is the most effective way to express a strategy for ship modernization that should be commonly followed by design, material management and

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[7]For a similar definition of pallet as applied to ship construction see Ship Production, by R.L. Storch, c.P. Hammon and H.M. Bunch, Cornell Maritime Press, 1988.

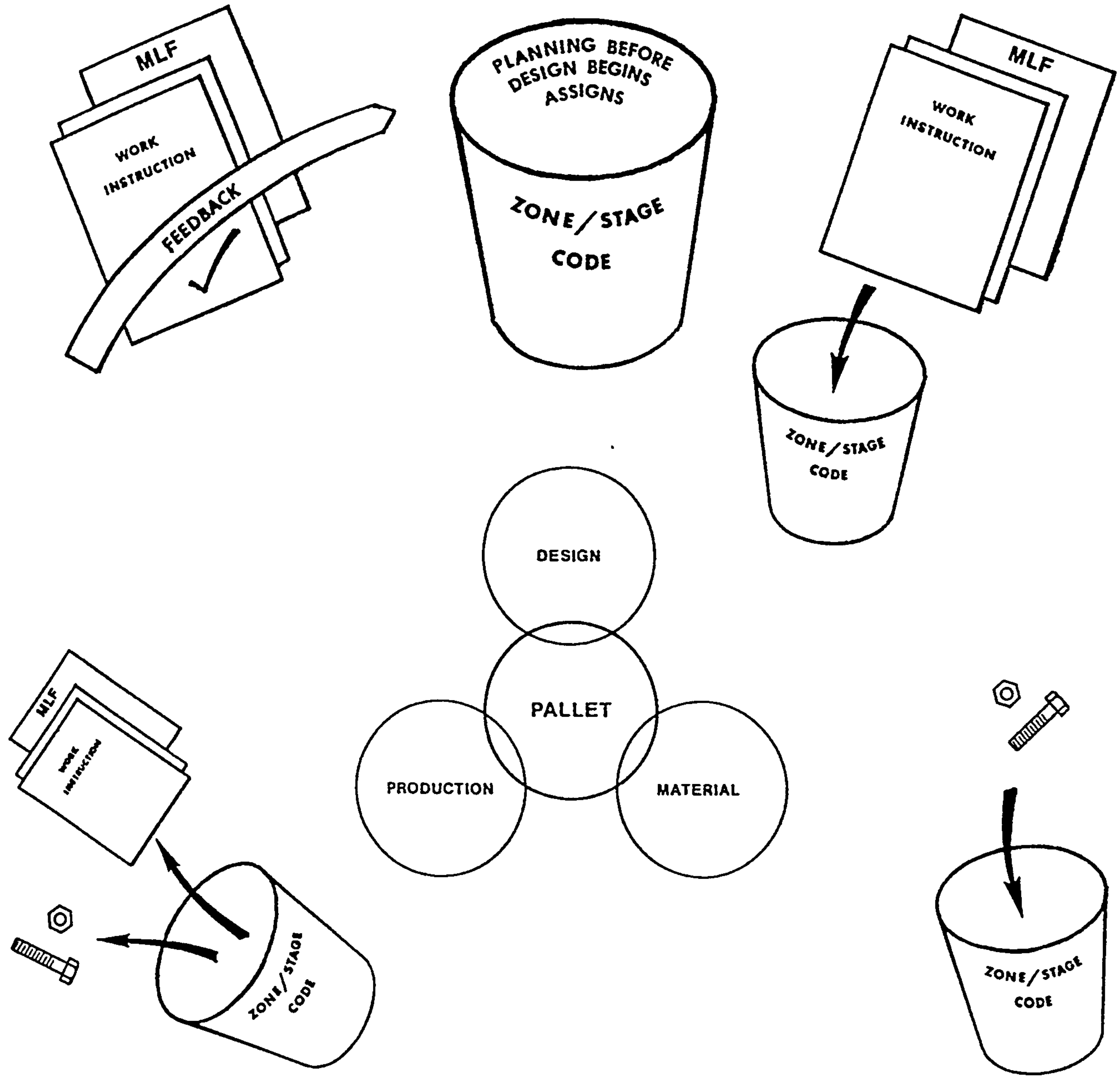

FIGURE 1-3: The pallet concept applied to ShipAlts.
Pallet = zone/stage = interim product = work package.

production people. As shown in Figure 1-4, a production-engineered strategy for simultaneous implementation of any number of ShipAlts can and should be given to ShipAlt designers at least before they start that part of basic design that will become contract design, that is, a negotiated package which first of all does not affect ShipAlt functional requirements, but is consistent with the most productive methods known. 8

Regardless of what they are called, pallet lists, zone/stage lists, or even interim-product lists, each is a strategy for coordinating design, material and production management. There is no counterpart to the powerful pallet concept in traditional system-by-system operations.

1.6 REAL AND VIRTUAL WORK FLOWS

Another profound benefit is derived from the pallet concept. Since identification of stages is for the purpose of providing separation by type of work regardless of systems represented, classification of each type of required work is said to be by problem area. With pallets sorted per zone/stage/area classifications all prerequisites are in place to fully exploit Group Technology (GT), even for disassembly and assembly work on-board. That is, when the problems inherent in required work are the same, interim products, regardless of even significant design differences, may be produced on rationalized work flows. The latter are analogous to the way inside machine shops in naval shipyards are exploiting GT by arranging machine tools into cells so that each cell addresses a frequently encountered set of problems for a mix of products of different designs that are required in varying quantities.

Rationalized work flows may be either real or virtual. Real work flows are characterized by the material being processed moving from work station to work station as on automobile production lines. Virtual work flows are

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8 "...work analysts have to participate in the design of the product and process. Obviously the finished product cannot be engineered primarily to make work easier. Its basic specifications are set by the needs and values of the user and not by those of the producer. But within the restraints set by these basic specifications, there is usually considerable leeway to design a product or service so as to be produced efficiently or inefficiently, simply or with unnecessary complications, with economy of work or wastefully." Management-Tasks, Responsibilities, ractices, by Peter F. Drucker, Harper & Row, NY, 1973, ISBN 0-06-011092-9, p. 201.

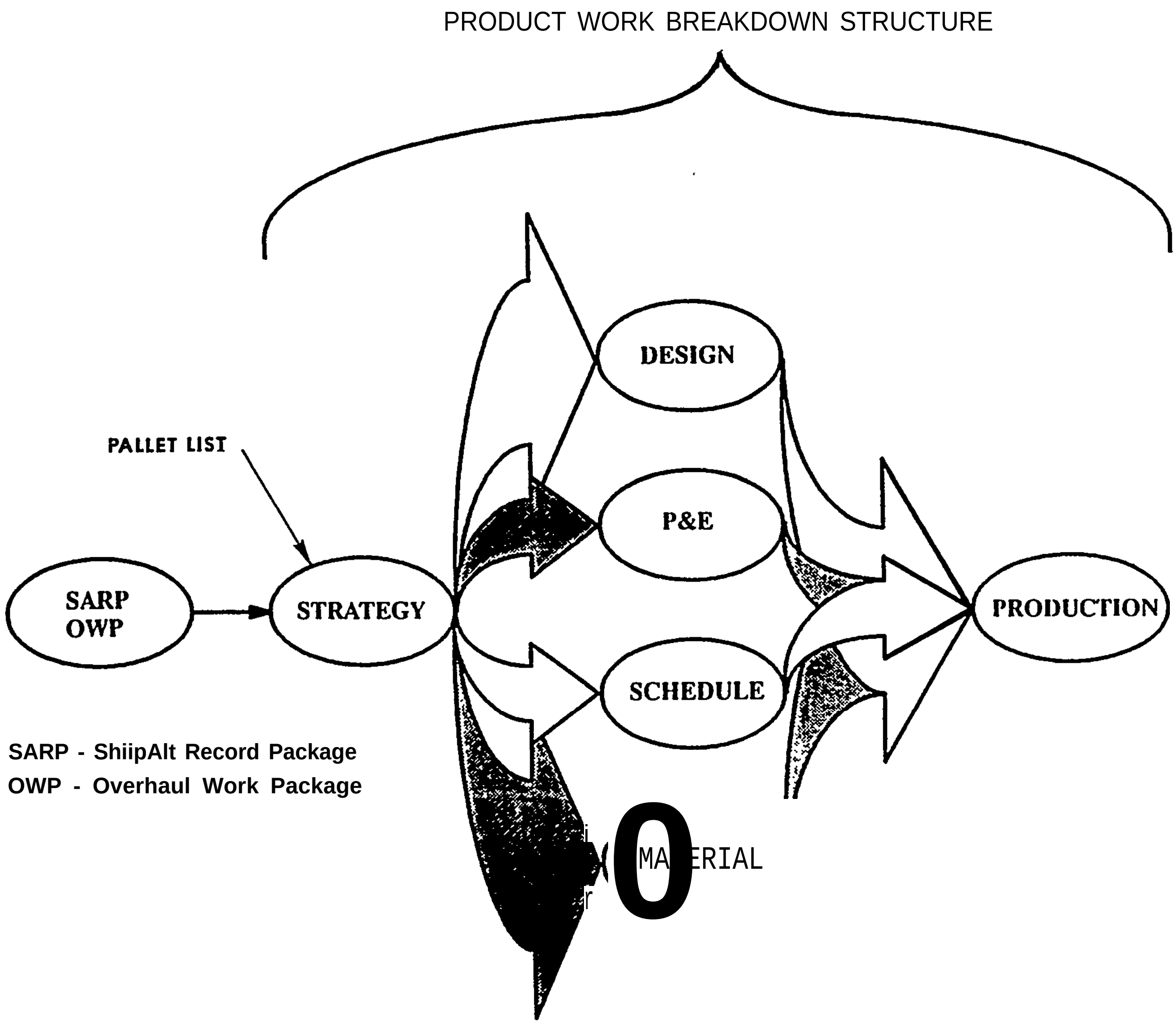

FIGURE 1-4: The zone approach characterized by strategic planning before design begins. The application of zone logic is greatly facilitated. (Provided by Philadelphia Naval Shipyard)

characterized by the material being processed remaining stationary and work teams moving from site to site as during construction of a kyscraper. Although applications should be minimized, there are always exceptions that are best handled by job-shop approaches. Work in shops may be performed on real flows (overhauling valves and manufacturing pipe pieces) or virtual work flows (assembling, outfitting and painting structural blocks for a close-in weapons system), whereas work on board can only be performed on virtual work flows (overhauling submarine ballast tanks).

1.7 DIFFERENCES BETWEEN SYSTEM-BY-SYSTEM AND ZONE/STAGE ORIENTATION

The most profound difference between traditional system-by-system and zone/stage operations is the former's absence of an overall production-engineered strategy before even basic design efforts start. A strategy imposed for zone/stage oriented operations is idealized when it is: initially applied in a large-frame sense, subject to constant refinement as more design information becomes available, and dependent more on ship type and nature of work rather than on details of the work to be accomplished. As a consequence of the latter, the physical separation of planning yard designers from implementing yards, while it still remains a problem, diminishes in significance.

Zone/stage operations feature design as an aspect of planning whereas traditional system-by-system operations are characterized by most of the design effort taking place in the absence of meaningful planning. Thus, there is little opportunity for quality production engineering. This difference is especially remarkable because for many years only naval shipyards among all shipyards in the U.S. have their design divisions organized as part of their planning departments. But while so organized, master planning (large-frame sense) is insufficient and untimely. The zone/stage approach requires more and better quality planning (literally an implementation strategy that acknowledges that other work will be taking place simultaneously) in time to guide ShipAlt basic designers. Further, a zone/stage approach requires refinement of the implementation strategy as design progress makes more information available. As shown in Figure 1-5, starting with basic design, imposition of a strategy or refinement of a strategy always precedes design activity.

Such refinement continues until just before the final ShipAlt design stage when production engineering input becomes tactical in nature. Detail designers are then advised of the exact way that production needs information grouped on final detail drawings. The latter, since they

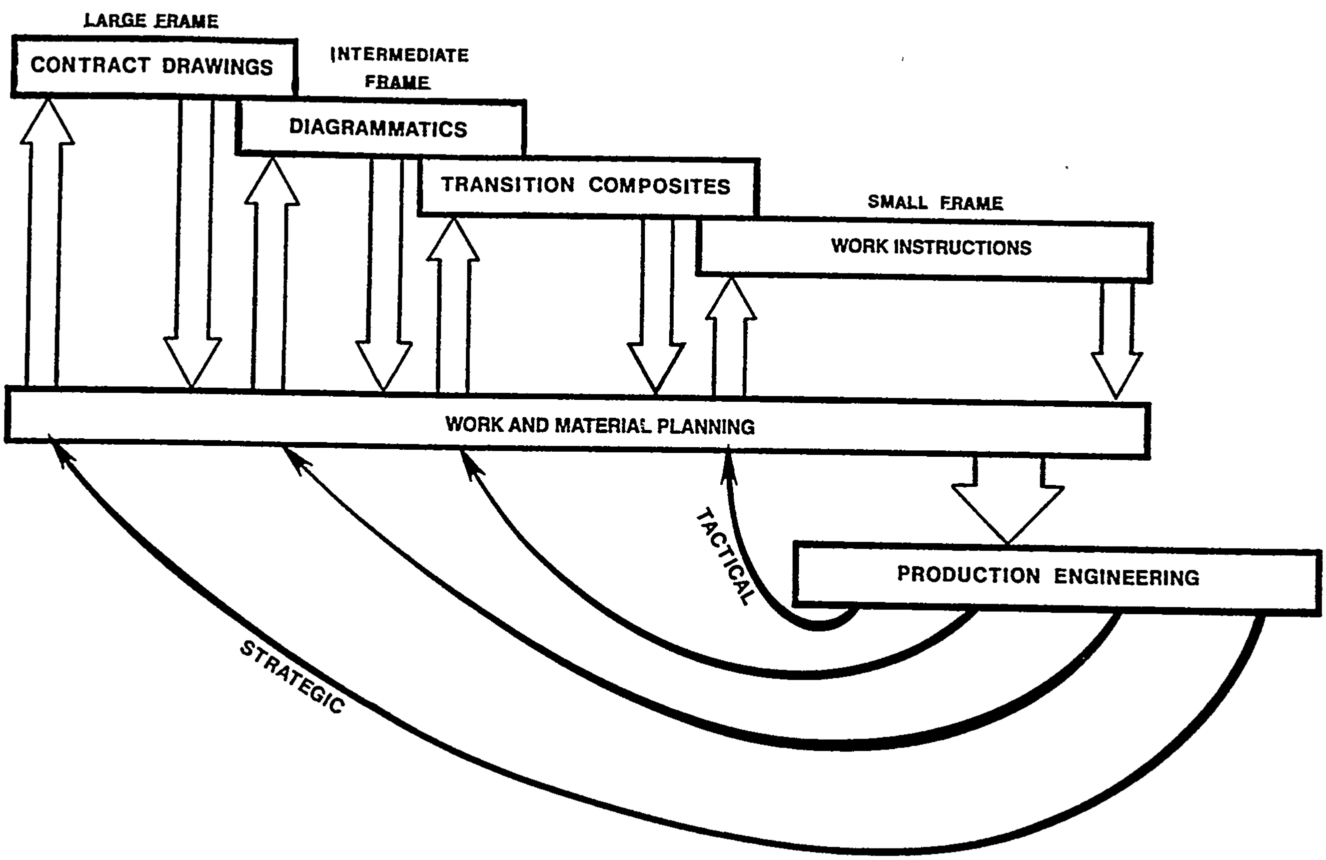

FIGURE 1-5: For effective ShipAlt implementation, production engineering inputs precede all design stages. Initially, the production engineering input is strategic and, as design progresses, it becomes tactical.

include more than just design details, such as, precautions, procedures for performing work, and reference lines that facilitate assembly, are becoming known as work instructions.

Unlike system-by-system design which is usually separate for each ShipAlt and also independent of other design activity, all stages of the design effort for zone/stage orientation are parts of a single process in response to a single strategy regardless of where design work is performed. Thus, information from planning yards to support zone/stage logic should conform to a strategy devised by a production engineering effort even if it is just for basic and functional design stages with the remaining design efforts performed by implementing yards.

I!Reference to any miscellaneous information relating to operations or procedures peculiar to a specific shipyard. . . . " is disallowed. But a production-engineered strategy, generic per ship class and hardly miscellaneous, does not preclude extracting data from a design model in the traditional system-by-system manner. Therefore, no conflict with the cited specification is envisioned. 9

1.8 DESIGN STAGES

As early as ***1986,*** at least one planning yard which was also the implementing yard, through a special planning effort for modernizing a submarine, combined several "electronicil ShipAlts that required extensive rip out and reinstallation work. Because information was to be grouped by type of work within a zone rather than by system, designers were able to combine foundations for adjacent electronic equipment even though they were for different systems. This made it practical to finish machine foundations in shops and to organize the activities on-board in distinct stages by type of work, including shoring platforms, ripping out, holding-coat painting, fitting requiring heavy welding, fitting requiring bolting or light welding, electric cable pulling and connecting~ and final painting, to be implemented for all ShipAlts simultaneously. Figure 1-6 illustrates a shop-assembled and shop-machined foundation for multiple-system electronic equipment in a submarine. Because of the foundation’s proximity to the

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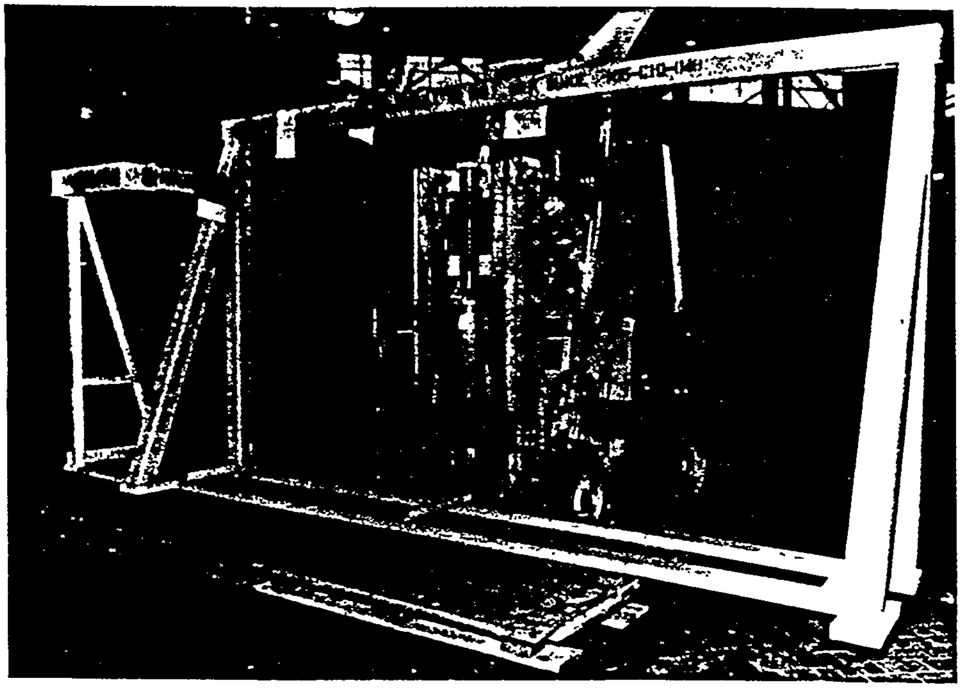
9 The quotation is from Technical Specification for Ship Drawing Preparation, No.-9090-600, 4 September 1984, Part 3.2.4e.



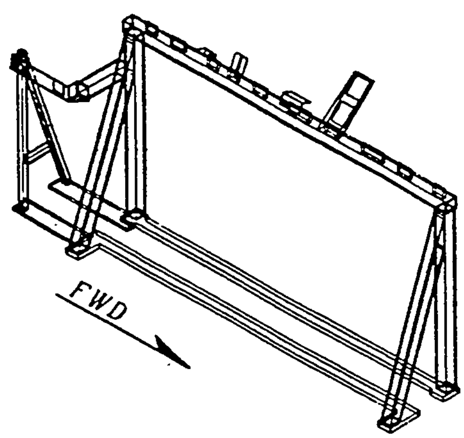


FIGURE 1-6: A common foundation for multiple systems which was completely manufactured in shops. The work included assembling, machining, and drilling. Previously, using traditional system orientation, such foundations were assembled, machined, and drilled separately for each system, on board a submarine. (Provided by Puget Sound Naval Shipyard)

curved hull, an accurate design model of the vessel was the first need identified when planning this extremely beneficial approach to work. 10

For various reasons, including relatively inaccurate hull structure and inexact as-built drawings, many drawings for naval ships cannot be relied upon for designing modifications. Traditional system-by-systems operations employ ship checks for the purpose of verifying the dimensions and locations of only critical or relatively large items. The resolution of interferences associated with other items is either referred to design when detected after work starts, or is resolved in the field by production. Those ‘Iremedial” efforts adversely affect productivity to a significant extent and have been continuing for years without addressing the root cause of the problem.

In contrast, zone logic forces improvement in the quality of design models as a means to assure that all work of one type, heavy welding for example, is accomplished during one stage without delays or need to perform heavy welding after another type of work, say light outfitting or painting, has started. Thus, a modernization strategy imposed at the start of ShipAlt basic design, should manifest itself at the end of the design process as just the information needed to perform a specific type of work during each stage defined by the strategy. Planning yards should clearly understand the nature, grouping, and refinement of information during all design stages.

The overall process, within which design should inescapably be part of planning, may be described as starting with basic design. Basic design involves system-by-system organization of information together with arrangements that are overlaid with a generic, basic implementation strategy. In other words, the information being compiled would be organized as a matrix. When examined from one aspect, information would be grouped by system. When examined from a second aspect, information would be grouped by zone in a large-frame sense.

The second stage, functional design, should produce quasi-arranged diagrammatic and key drawings by system which fix functional aspects and which represent a degree of refinement of basic design. At the same time the zonal view of the information matrix would reflect a better, but not yet final, implementation strategy. This information grouping is said to be organized in an intermediate-frame sense.

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10 "Increasing Efficiency Through Outfit Planning by C.M. Murphy, Journal of Ship Production, February 1989j”pp.-l-9.

Both the first and second planning stages require ShipAlt designers to define all materials required (design is an aspect of planning). By that is meant definition by either (a) exact identities and numbers required, (b) exact identities and estimated quantities, and/or (c) identification by material classes and estimated quantities, such as, “so many "lineal feet of medium-diameter electric cable.

Material definition should be refined to an intermediate degree during the second stage. The. quasi-arranged diagrammatic should be subdivided by intermediate zones so that the location and receipt date requirements for certain materials may be estimated with enough assurance to initiate their procurement. This emphasis on material definition is extremely important. Many difficult to procure items, valve operators for example for which procurement in a system-by-system approach would be initiated relatively late, can and should be ordered from functional design information. The information is derived from a matrix that simultaneously identifies information grouped by systems and by zones in an intermediate-frame sense, that is in the context of a now refined generic, basic implementation strategy.

The third stage, transition design, requires the least number of man-hours, and should be implemented by experienced people having simultaneous understanding of ship operational, ship maintenance, and shipyard productivity matters. At this stage all information is l’transitionedll to zone orientation. Transition designers establish the final routing of new and/or modified distributive systems per required ShipAlt arrangements and in the context of a finalized modernization strategy. Transition designers establish the rights-of-way for ShipAlt distributive systems, locate the positions of such things as valves and gages relative to machinery, delineate the space reservations required for maintenance, and show interface boundaries that zone-oriented detail designers are to observe. Whether or not subsequent efforts produce maintainable designs is very dependent upon the knowledge and expertise of those who perform transition design. Their outputs, plus the planning yard’s file of standard details are all that are needed for effective control of detail design, that is, the final stage which produces information grouped in a small-frame sense. While the transition effects some degree of design refinement, it does not address material refinement.

As a consequence of design being regarded as an aspect of planning, the final or fourth stage, is also referred to as work instruction design. Instructions regarding safety, work procedures, disposition of ripped-out materials, etc., supplement design details and material lists. In some naval shipyards the final design products are referred to as unit work instructions. They are organized in 8 l/2"xll" booklets that are subdivided so that each segment provides all information required to perform work in a specific zone during a specific stage regardless of different systems. 11

Also, this final stage incorporates the detail requirements for producing pipe pieces and components other than pipe pieces. Thus, the entire planning process starting with basic design is one of constantly subdividing and sorting information. 12

1.9 THE PRODUCTION ENGINEERING FUNCTION

The idea that is understood by too few public and private shipyard managers as of 1990, is that production engineering is most effectively applied as a decentralized pervasive function which has two objectives for each undertaking:

- o completion of a project to the customer’s satisfaction, and
- o manifest improvement in the implementing yard's manufacturing system during execution of the project.

If one of the objectives is achieved without the other a shipyard manager has failed. Both directly impact on the Navy's mobilization potential. Because implementing yards do not have enough understanding of the imperative need for both objectives, they have not, as of 1990, made sufficient pertinent demands on planning yards. Nor have Navy project and program managers, because their missions do not include constant development of manufacturing systems.

"Such work instructions for "building, outfitting, painting, and testing a four compartment module. ..for a new weapons system” in USS TEXAS (CGN-39) are described in “Unit Work Guide for Zone Outfitting in Repair and Overhaul,!l by S. Kjerulf, Journal of Ship Production, May 1987, pp. 95-110.

12 In an analysis of information needs on drawings produced at different stages of the design process, it was determined that “modular type of drawing will actually meet their (Navy) needs better than the individual system drawings”, from "Zone-Oriented Drawings For Life Cycle Management," The National Shipbuilding Research Program, September 1988. Thus the design procedure described here will not adversely impact any other U.S. Navy ship life-cycle information requirements.

Imposition of a production-engineered strategy even as basic design starts and constant refinement of the strategy as subsequent design stages make more information available, is a shipyard manager's way of saying, "I have to protect the methods which enable me to constantly improve the manufacturing system." Thus in competition, a close association between production engineers and designers, 'wherever they are located, is essential for a shipyard's survival and for the Navy's ability to get the greatest return from available funds.

Ideally, a production engineering effort requires a few dedicated high-level production engineers from an implementing yard at time of basic design, a larger number of field engineers who are regularly assigned to shops at time of functional design, the same high-level production engineers at time of transition design, and the actual foremen who will supervise the work at time of detail design; see Figure ***1-5.*** Regardless of their positions, all would understand that their participation in decentralized production engineering is a regular work responsibility.

While sharing their predecessors' concerns for safety and productivity improvement, foremen, in their production engineering roles, would be primarily concerned with inputting things of a tactical nature, such as, dividing a pallet into smaller work packages and specifying rip-out sequences. Thus, required lead times and work volumes would be greatest for high-level production engineering, would reduce commensurately through the intermediate level, and would be least when foremen provide their inputs (about four to six weeks ahead of scheduled starts for work volumes in the order of forty to 120 man-hours).

In each design stage for a vessel modernization effort, the totality of the project is always discussed but in a different level of detail. For example, during basic design there are relatively few information groups visible from the zone side of the information matrix, each are relatively large, and the information contained is relatively vague. Subsequent design stages increase the number of groups, decrease their sizes, and provide more exacting descriptions of modernization requirements. Information becomes available at an expOential *rate.* As a consequence, more and moTe people are required to participate in the production engineering function in order to constantly analyze a developing design and to constantly refine (not change) the strategy.

But in most instances implementing yards are not yet designated when ShipAlt basic design starts. Rather than proceed in a production engineering vacuum, design work should proceed in the context of a basic ship modification strategy that is peculiar to a ship class until an implementing yard is esignated. Further, a few qualified production engineers should be employed in each planning yard to act as if they were in a zone-oriented implementing yard until an implementing yard is designated.

1.10 MATERIAL/MAN-HOUR RELATIONSHIP

The effective application of zone/stage logic requires production control primarily through control of material. Great emphasis is attached to early definition of ***all*** required materials from the earliest design stage and constant refinement thereafter as described in Part 1.8. Man-hours required to process material should be related to some physical characteristic of material, such as, weight, lineal footage, and surface area. Thus the initial assessment of material required during basic design is the basis for determining total man-hours required and for their initial allocation in a large-frame sense. The man-hours obtained should be the primary inputs for establishing a master schedule. As material is further defined in subsequent design stages, man-hour allocations and schedules should be further refined.

The man-hour/material relationship facilitates use of a computer to constantly compare materials being defined during each later design stage to those predicted in basic design. As soon as unforeseen materials or unforeseen quantities are disclosed (due to design development or open-and-inspect activities), managers are warned to adjust or confirm existing man-hour budgets and schedules. This constant comparing, through development of zone/stage work packages and the evolution of weekly man-hour budgets and schedules, is extremely important.

1.11 PRODUCTIVITY INDICES AND ANALYSES

The concept of the material/man-hour relationship should also be used to establish work volumes in work packages. The terms material volume and work volume are synonymous. Thus, a material list for an interim product should be the basis for determining man-hours required for producing the interim product. Man-hour costs should be collected per interim product or obtained by proration after man-hour costs are reported for a series of interim products of the same type of work. The man-hour costs relative to certain physical characteristics of the materials being processed are productivity indices (man-hours/number of pipe pieces ripped out, man-hours/parametric weight of fittings assembled, man-hours/cable length pulled, etc.). [13]

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13 parametric weight relates to only the weight of those

Because each productivity indicator is per type of work and the planning provides for performing each type of work in a specific zone during a specific stage, the incidence,of different work teams conflicting with each other is all but eliminated. In the absence of such conflicts and where work flows per type of work exist, statistical analyses of man-hour cost returns are extremely effective. Implementing yard and planning yard managers are then informed much more exactly about how work is being performed. Analytically derived answers are obtained to the questions:

- How does the progress of work compare to weekly, biweekly, monthly and higher-tier budgets and schedules?
- Is constant improvement manifest?
- Are there other trends?

Design becomes a true aspect of planning. Total Quality Management (TQM) becomes a realistic objective because, as shown in Figure 1-7, everyone in the design hierarchy is kept aware of how their activities impact on cost/interim product.

1.12 SUMMARY

Basic ShipAlt designers account for the least expenditure of man-hours, but have the greatest impact on total ship modernization cost. Other designers and material management people account for a greater amount of man-hours and have the next greatest impact. Production people, while accounting for the greatest expenditure of man-hours by a wide margin, have very little impact on total ship modernization cost, see Figure 1-8. Thus, the key to productivity improvement is in more and better quality ShipAlt planning which will direct design and material management to exactly anticipate how production will be implemented. This goal cannot be obtained via traditional system-by-system operations because each ShipAlt designer usually performs more or less independently and in the absence of an overall strategy that would describe how production is to be implemented.

As of 1990, a few private shipbuilding firms which also perform ship modernization and one naval shipyard have successfully adopted zone/stage logic for their overall

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items in an envisioned work package that have a sufficiently useful relationship (statistically verifiable) to man-hours required to implement the entire work package. Other weights are ignored.

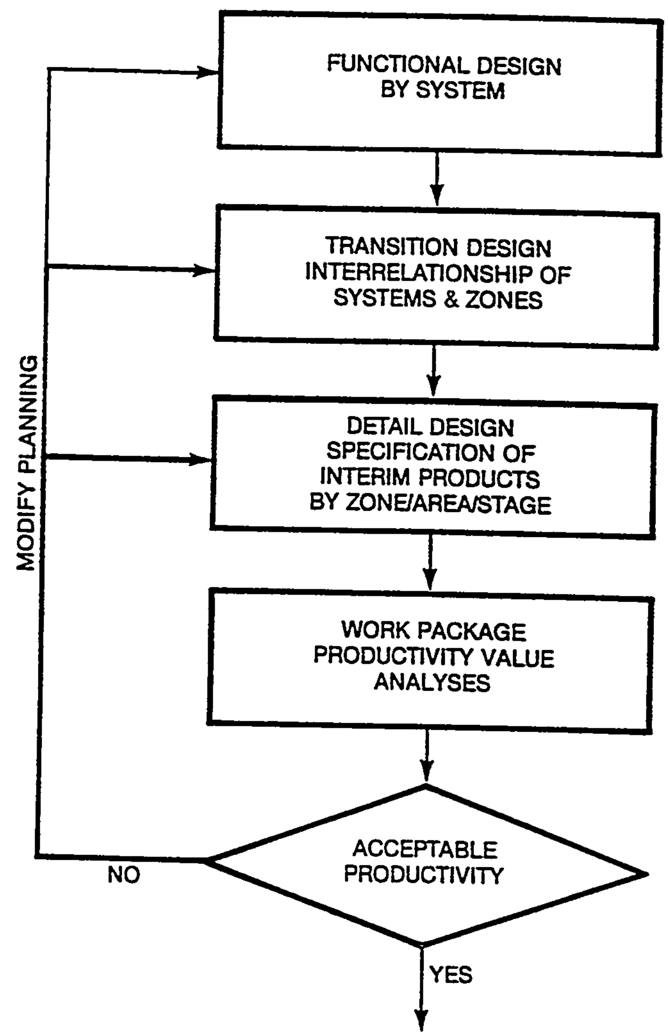


FIGURE 1-7: The reiterative development of work packages. Design and material definition are regarded as aspects of planning.

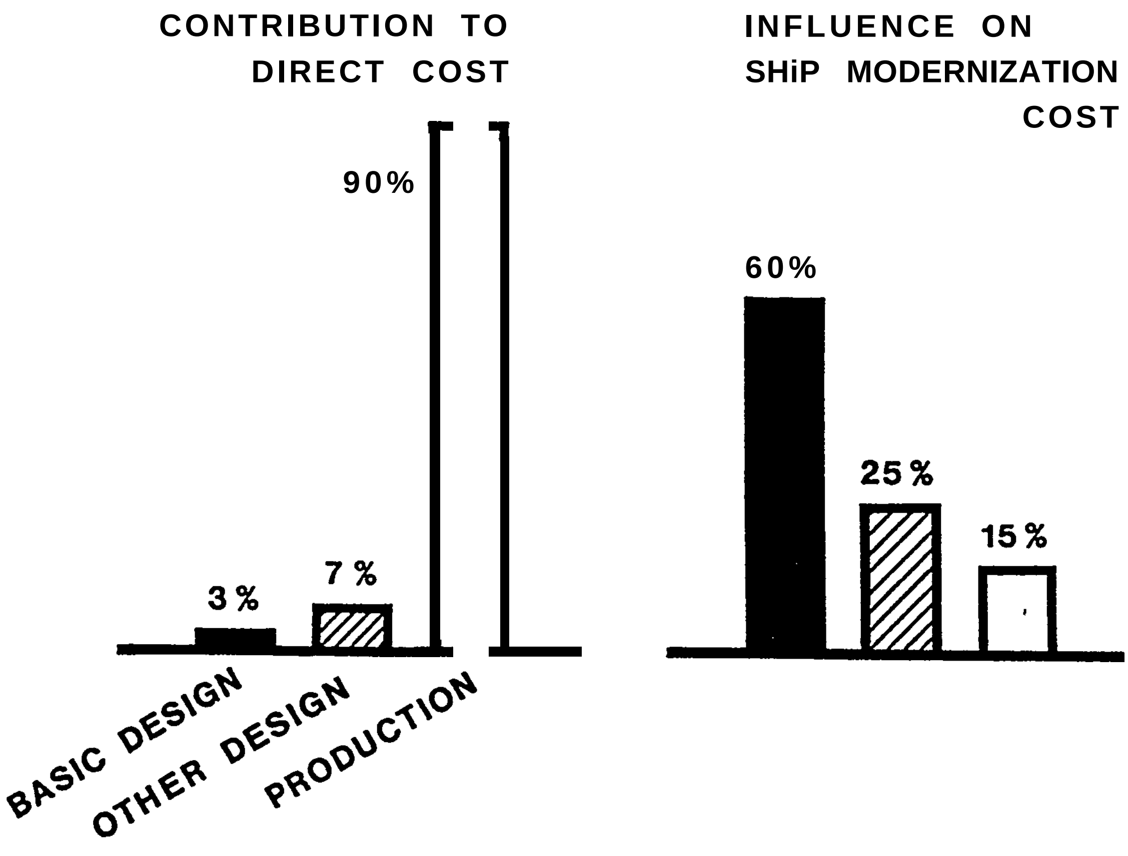


FIGURE 1-8: A comparison of direct cost to its influence on ship modernization cost. The percentages shown are typical of work performed in shipyards.

operations. Other naval shipyards have successfully employed limited applications of zone/stage logic in various surface ships and submarines, usually for installation of complex weapons systems. Adoption of zone/stage logic by planning yards is essential for more implementation in both public and private shipyards. Changes in the way planning yards operate have to overcome the tollowing problems:

- o planning yards are often separated from implementing yards,
- o planning yards often start before implementing yards are designated, and
- o planners, designers, and production people, in both planning and implementing yards, who are specialized by function, are reluctant to accept substitution of expertise by product.

Thus, this publication provides guidance to planning yards about the nature and grouping of design information needed for basic zone/stage strategies that implementing yards may employ. With the momentum thus gained, an implementing yard, when designated, would only have to negotiate:

- o nominal changes in a strategy, and
- o assumption of certain remaining design responsibilities.

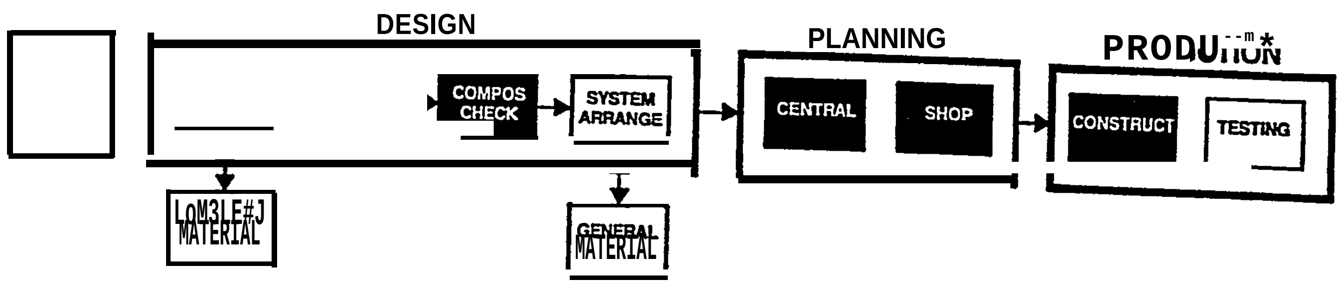
Regardless of the split design responsibilities, it would seem that the manufacturing process for a ShipAlt commences with the start of contract design, that is, all design, material marshaling, and production activities would be in accordance with a single strategy (see Fig. 1-9) .

But the development of a sufficiently useful generic strategy per warship class requires significant expertise and resources complimented by some ball park understanding about the scopes of modernization efforts two to four years in the future. For example, would wholesale renewal of weapons systems be likely? Are extensive structural modifications probable?

Strategies to the extent that they are described herein, are only intended as models. It is strongly recommended that sufficient funding and high priority should be applied for retaining production engineers who have extensive experience in applying zone logic for shipyard applications. They should work with teams of planning yard designers and prospective production engineers to further develop basic strategies for classes of carriers, submarines, surface combat hips, and uxiliaries. 14

14 Philadelphia Naval Shipyard utilized experts provided by IHI Marine Technology, Inc. to develop the zone logic strategies and related services for modernization of both KITTY HAWK (CV-63) and CONSTELLATION (CV-64) as described in "Strategizing and Executing the Implementation and Utilization of Zone Technology at Philadelphia Naval ShipyardrIt by L.D. rill, B.S. Munro, M.S. O!Hare, and K. Baba, Jornal of Ship Production, August 1990, pp. 164-174.

Traditional System Orientation



Modern Zone Orientation

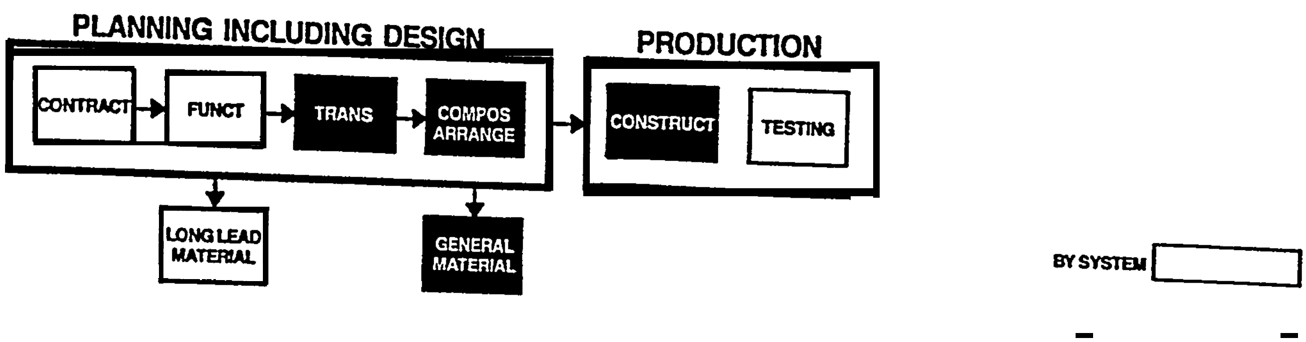


FIGURE 1-9: Traditional vs. modern manufacturing systems. The former features planning after design. The latter features more and better quality planning before each design stage. The consequences of the greater investment in planning are significant reductions in both durations and man-hours required.

2.0 BASIC STRATEGY

2.1 SPECIALTIES

System-by-system operations start with knowledge of a craft, whereas zone/stage (product-oriented) operations first address the requirements of a product. The interim products featured in a product work breakdown structure (PWBS) determine how skills (people), information, and materials are grouped. For example, because the problems associated with modernizing electronic spaces are significantly different from those required for such work in machinery spaces, the needed groupings of skills, information and materials are different. Each grouping is specialized for a different set of challenges.

The number and nature of required specialties are dependent on ship type and are applied for design just as they are for production. An auxiliary ship may require specialties only for machinery, accommodations, electrical/electronics, and a category sometimes called deck that includes everything else (see Figure 2-l). For overhaul and modernization of an aircraft carrier, the most extensive application by a naval shipyard, ten specialties may be employed:

- o Services, dock work and miscellaneous.
- 1 All tank work (cleaning, painting, piping, structural, testing) , tanks tops, and hull structure.
- 2 All work in main machinery spaces and associated shaft alleys (except tank-top repairs) .
- 3 Auxiliary machinery spaces and all associated work (except tank-top repairs).
- 4 All magazine work (except tank-top repairs).
- 5 All pump room work, emergency-generation spaces, air-conditioning spaces, and rudder work.
- 6 Spaces from third deck to main deck (primarily, but not limited to, accommodation spaces) .
- 7 Hangar bay.
- 8 Spaces from main deck to flight deck (primarily electrical/electronic spaces) plus island.
- 9 Flight deck.

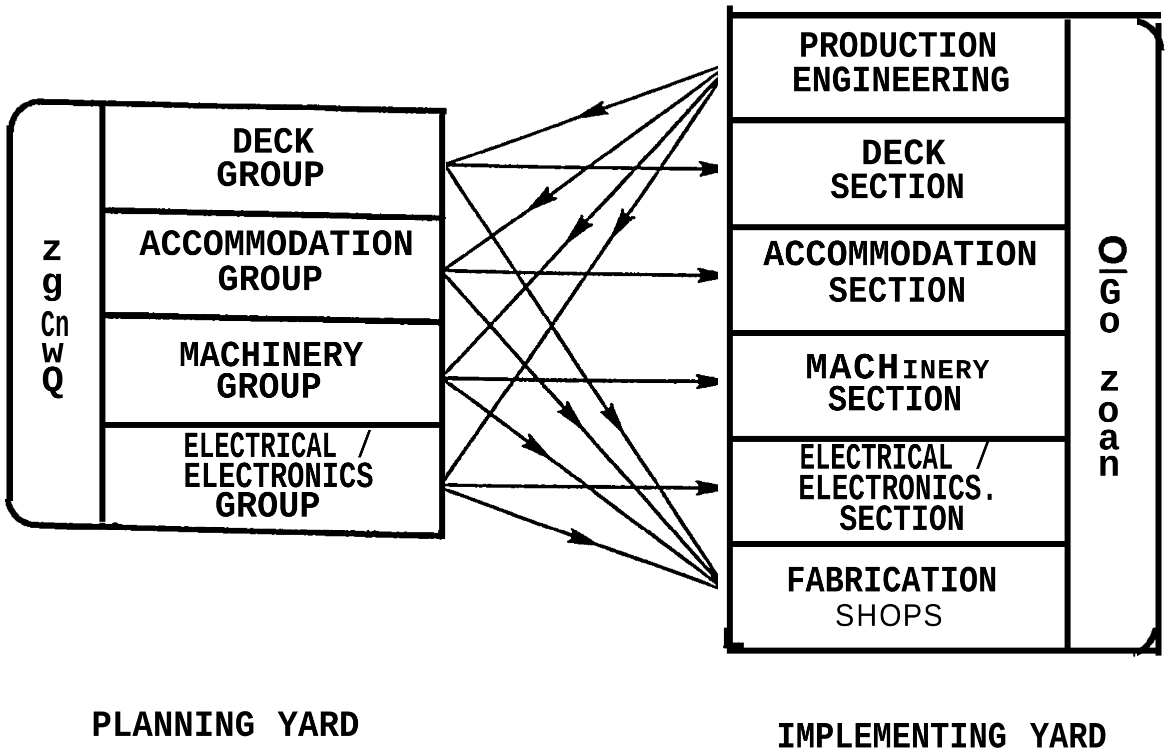


FIGURE 2-1: Expertise in designing and manufacturing parts and assemblies per problem area is substituted for traditional functional expertise.

How they are imposed is illustrated in Figure 2-2.[1]

The specialties shown only denote basic separation by problem categories, an aspect of Group Technology (GT). Figure 2-2 also shows that a multiplicity of regions having the same problem category (Specialty 5) are not contiguous to each other nor do they conform with main structural divisions. This is because they represent separation by problem category only.

Geographical representation of a specialty simply designates a sphere of responsibility assigned to a design team and its companion team in production, that have interim product expertise peculiar to a specialty. In some yards the word zone is used in place of specialty. Problem zone or any other term that implies separation by problem category is preferred. The reason for this distinction is to avoid confusion with later usage of the term zone/stage.

As described in Part 1.3, zone denotes a geographical division and stage refers to a separation in time. Control of work may be achieved by either one, but the most flexible and most effective way to control work is by their usage in combination, zone/stage. If a particular zone is opportune at one point in time, it does not have to be retained if it is not opportune at a different time. For example, structural work on a bulkhead requires a zone that encompasses the bulkhead with sufficient space reserved on each side to facilitate structural work. Later on a zone that is made up of one or more compartments makes better sense for painting work. Such usage of zone/stage for electric cable pulling through all specialty regions is a better and more complex example.[2]

Obviously zone/stage work packages often have to straddle the boundaries between specialties. In each such case, the different specialists have to coordinate their planning with each other.

Packaging work by zone/stage per specialty is means to assure that different work teams are not unintentionally in the same zone at the same time. There is no counterpart

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1 "Strategizing and Executing the Implementation and Utilization of Zone Technology at Philadelphia Naval Shipyard," by L.D. Burrill, B.S. Munro, M.S. O'Hare, and K. Baba, Journal of Ship Production, August 1990, pp. 164-174.

2 "IHI Zone Logic Application to Electrical Outfitting on Highly Sophisticated Ships," by S. Sato and S. Suzuki, Journal of Ship Production, May 1990, pp. 93-100.

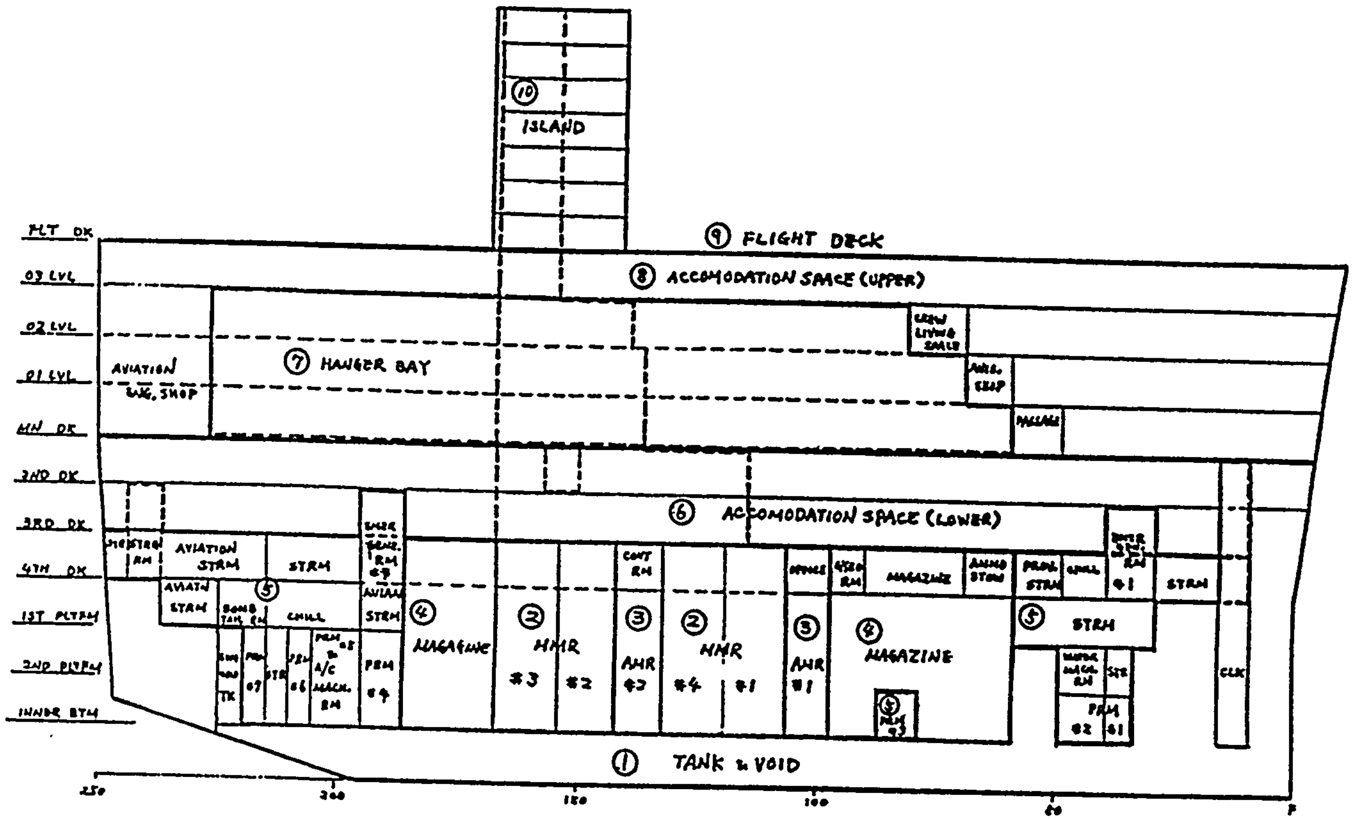

FIGURE 2-2: Specialties employed for modernization of an aircraft carrier. (Provided by Philadelphia Naval Shipyard)

planning technique in system-by-system operations. Therein, workers have to compete for access to on-board work, because the planning performed for them is incomplete.

Also, zone-oriented production engineers are able to advise designers of a manufacturing system's most effective work flows. From the beginning and through continuous interaction with designers, their objectives include getting as many zone/stage work packages into preferred problem areas. That is, as much as possible work is performed in rationalized work flows. Job shop work is minimized.

As prerequisites for effective implementation of zone logic, the specialty regions and planned zone/stage/problem area classifications of work have to be considered even for the earliest required ShipAlt Installation Drawings (SIDS) and their attendant bills of material (BOMS) .

2.2 LARGE-FRAME PLANNING

Each specialty in design and its production engineering counterpart, basically proceeds as if the region for which it is responsible is a separate ship. Of course there must be coordination with other specialists at numerous interfaces, some of which can be very significant.

With only the earliest available information, such as Ship Alteration Proposals (ShipAlt Proposals or SAPS), and knowledge of a ship class, production engineers/specialty are able to negotiate with customers and designers in order to create a mutually acceptable pallet list (strategy). This is not particularly difficult for specialists because they only have to express a strategy in terms of zone/stage/problem area designations. Specialty Number I for tanks and voids, as shown in Figure 2-2, provides the simplest example. Zone/stage/area work packages could be sequenced by the specialists to start aft and go forward as a single work flow or, production manpower permitting, as two flows progressing side by side. Also, each zone could address a single tank or a group of adjacent tanks dependent upon the degree of control desired.

For tank cleaning, scaffolding and temporary service installations, holding-coat painting, inspection, and the rip out of fittings, it makes sense for zones to coincide with boundaries formed by structure. For rip out and replacement of structure, zones that encompass the structural boundaries are required. Thereafter, zones that are made up of single tanks or groups of tanks should again be employed for installing fittings and for painting. The clever composition of a zone/stage list insures, for example, that a team dismantling fittings on one side of a bulkhead is not endangered or disrupted by people assigned to make cuts through the bulkhead from its other side.

The sequence for work is organized like a series of rolling waves, wherein the crest of each represents a category of work (problem area) . Thus the team assigned to tank cleaning leads, followed in succession by other teams with zone/stage control assuring that no two teams are unintentionally in the same zone during the same stage.

Another example which pertains to extensive modernization of an electronic space could employ two zones that are separated by a horizontal parting plane at about midway between the deck and the overhead, that is, upper and lower zones. A generic pallet list for such spaces could be:

Zone	Stage	Problem Area
Complete Space	1	Tagging equipment and fittings with disposition instructions.
Complete Space	2	Disconnecting electric cables.
Lower Only	3	Removing equipment and fittings that do not require extensive gas cutting.
Lower Only	4	Removing electric cable.
Lower Only	5	Removing fittings, including foundations, that require extensive gas cutting.
Complete Space	6	Removing insulation.
Upper Only	7	Removing electric cables.
Upper Only	8	Removing fittings that do not require extensive gas cutting.
Upper Only	9	Removing fittings, including foundations, that require extensive gas cutting.
Complete Space	10	Clean and prime.
Upper Only	11	Fitting by heavy welding.
Lower Only	12	Fitting by heavy welding.
Complete Space	13	Touch-up followed by lst-coat painting.
Upper Only	14	Fitting by light welding and bolting.

Lower Only	15	Fitting by light welding and bolting.
Complete Space	16	Touch-up followed by remaining painting.
Complete Space	17	Equipment tests.

This pallet list should be thought of as a series of empty buckets of varying sizes, that have yet to be filled with the detail design information, materials, and skills needed for realizing a series of different interim products (see Figure 1-3).

Obviously, zone/stage/area planning for rationalized work flows means more and better quality planning that first impacts on the sequencing of design development and on how design information is grouped.

Thus the earliest produced SIDS, such as General and Machinery Arrangements, should incorporate identification of the specialties that will be involved, the extent of their involvement, the boundary areas that require special coordination by two or more specialties, and the basic, often generic, pallet definitions. In addition to the locations for major equipment, lists of all material required should also be grouped to match the specialties, but only as (a) exact identities and required numbers, (b) exact identities and estimated quantities, and/or (c) identification only by material classes and estimated quantities. This material compilation, broken down by specialties and the corporate history of man-hour/material relationships comprise a solid framework for the largest frame budgets and schedules. Beyond a shadow of doubt, planning that is consistent with Zone Logic vastly improves the quality of information in ShipAlt Record packages before they are sent to cognizant approval authorities.

The process for ordering major items that are classed as both Centrally Provided Material (CPM) and Long Lead Time Material (LLTM), with information thus far available, is not different from that traditionally employed.

Planning in a large-frame sense, the first time interaction of production engineers and designers, is represented in Figure 2-3. The first of the SIDS produced, such as general arrangements, in addition to reflecting commitment to meet customer requirements, contain the strategy framework achieved by production engineer/designer negotiations. The framework, like an armature used when sculpturing with clay, is susceptible to refinement but not to change per se. Thus, the SIDS which are the equivalent of contract drawings in the commercial world, should document

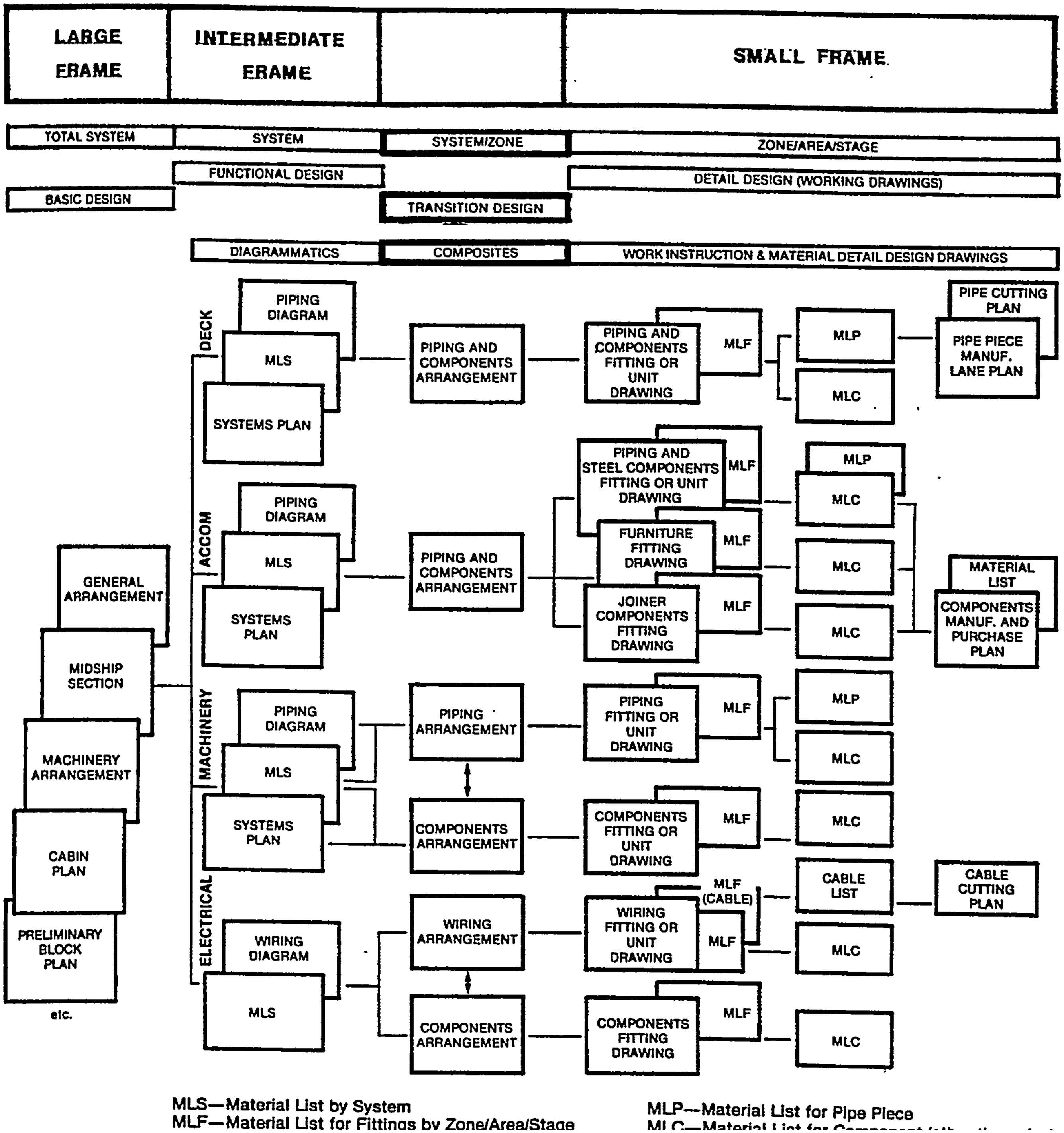

FIGURE 2-3: The typical product-oriented design process for construction is applicable for ship modernization when supplemented with other appropriate specialties.

productions commitment to a strategy before the major expenditure of design man-hours. In the traditional system-by-system approach to ship modernization, this critical need for early documentation of production's intent, is left virtually unfulfilled, is of insufficient quality, and/or is based upon an archaic approach to work. During at least the year before the start of a ship availability, traditional design and material managers can only do,the best they can, largely in the context of different personal experiences, to anticipate how information and material should be grouped to facilitate production.

Actually, the zone logic planning thus far regarded as large-frame planning, leapfrogs ahead into small-frame planning when the specialists provide previews, their pallet lists. These however, are the empty buckets, identified by title and code, which are still unrefined and which have yet to be filled with the detail design information, materials, and skills needed for realizing a series of different interim products.

2.3 INTERMEDIATE-FRAME PLANNING

Intermediate-frame planning, in addition to functional design, is chiefly concerned with production and material control matters that considerably refine cost/schedule data. It provides good enough estimates of certain materials, other than CPM or LLTM, for which special control and release of purchase orders before detail design starts, are extremely beneficial.

Approval authorities would further benefit because functional drawings are required to be more sophisticated than those traditionally prepared. All aspects that affect safety and operations are included (in the commercial world that includes virtually everything for U.S. Coast Guard and American Bureau of Shipping approvals). The objective is to minimize, if not eliminate, the need to submit drawings for approval after relatively intensive detail design efforts begin. Further, designers are required to quasi-arrange diagrammatic.

Each Material List per System (MLS) still addresses all materials required for a system. But because more information is generated during functional design, a MLS reflects considerable refinement. The identities and quantities of more material items are exactly known. Thus, a MLS, while not yet exact, contains fewer identifications by just material classes and fewer estimates of quantities required. 3

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3 As of 1990, a number of private and public shipyards have

The most advanced application of zone logic features a computer program to compare materials as they are being defined in the intermediate-frame planning stage to those which were identified during the earlier large-frame' planning stage. The program sorts and collates in order to answer two questions:

- o Are any materials now being defined for the first time?
- o If not, do quantities now being defined exceed those in the material budget developed as part of contract design?

Newly identified and/or revised quantities of materials are immediately addressed by material managers for their procurement significance . But more important, because of the material/man-hour relationships derived from corporate history, approval authorities and others concerned with production control, before an implementing yard is designated, are simultaneously being warned by the computer that man-hour budgets should be adjusted and schedules should be confirmed or changed accordingly. The terms material volume and work volume are synonymous. This computer program is the most important computer application for effective shipyard management. 4

Another profound improvement in the content of ShipAlt Records results from production engineers per specialty having to divide the regions for which they are responsible into a reasonable number of intermediate zones (in warships perhaps as few as five and as many as fifteen for each specialty) . Further, production engineers are required to sequence the intermediate zones consistent with how they plan the progression of work.

The boundaries of intermediate zones and their sequencing do not have to exactly encompass a group of zones/stages defined in previously conceived pallet lists, because

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adopted Material List per System (MLS) to replace Bill of Material (BOM) because the former is consistent with a scheme for identifying structured material lists, Material List of Fittings (MLF), Material List per Pipe Piece (MLP), and Material List per Component Other Than Pipe Piece (MLC) . Each MLC identifies materials required for a specific fitting, such as, a multiple system pipe hanger, foundation, or ladder.

[4] This approach to production control through control of material, the only tangible resource, was developed by Ishikawajima-Harima Heavy Industries Co., Ltd. (IHI).

intermediate zones/stages are only used to get better estimates of material and work volumes as needed for:

- man-hour budgeting and scheduling in an intermediate-frame sense, and

- issuing purchase orders for certain materials, which specify just-in-time deliveries in relatively small lots, immediately upon designation of an implementing yard, that is, without having to wait for material lists which accompany later prepared detail design drawings (the same information could also be used for establishing CPM and LLTM just-in-time delivery dates) .

As means to achieve these objectives, functional designers should overlay their quasi-arranged diagrammatic on the defined intermediate zones. The overlays then show what portions of various systems are likely to appear in each intermediate zone. Functional designers should also make corresponding divisions in each MLS.

The latter action sets the stage for release of initial purchase orders that specify just-in-time deliveries for certain materials, before detail design starts. Thus, the name Material Ordering Zone (MOZ) is used in place of Intermediate Zone. Material procurement gets a tremendous jump start.

Despite provision for CMP and LLTM, traditional material management is inadequate for increasingly complex ShipAlts. The problem is acerbated by the imperative need to shorten ship availabilities.

An extremely effective solution employs the MOZ concept in combination with a material classification scheme which gets designers involved in material planning (identification of function, quality, and quantity). This planning proceeds in accordance with a priority sequence which addresses imminent requirements and defers detail material planning for zone/stage/area work packages that are not required by production until later.

The scheme categorizes materials as:

Allocated Materials (A) - Sometimes called direct materials, they are ordered in response to very specific requirements. They are usually also classed as CPM and LLTM, such as, complex electronic consoles and missile launchers. As such they are of immediate concern to customers. Items that are exactly defined for the first time in planning yards or even in implementing yards, may also be classified as A material, for example, a unique electric motor controller or a specific length of very special electric cable. A materials require utmost attention during design, purchasing and production planning.

Stock Materials (S) - These relatively inexpensive items are used for many shipyard projects and are automatically reordered when stocks are depleted to predetermined levels. Examples are ordinary bolts, pipe flanges, and commonly used electric cable such as for lighting circuits. S materials do not normally require specific material planning.

Allocated Stock Materials (AS) - These are too expensive to maintain as S materials, and impractical to control as A materials because of the moderate qantities required. Examples are large valves, valve operators, and relatively expensive electric cable that are not stocked by suppliers. While they are shown in suppliers' catalogs, they are manufactured only in response to specific orders. Because they are moderately LLTMs, prudence dictates combining the characteristics of A and S materials so that as specific needs are defined, AS materials are ordered periodically and always with modest quantity margins. This approach, which features reassessment usually at the end of each month, maintains a sufficient stock for known and contingent requirements pending reorders in response to further material definition. [5]

Of the three classifications only AS is without precedent in traditional operations. Combined with the MOZ concept, the AS material concept enables a planning yard to release some purchase orders, or at least have them ready, before an implementing yard is designated. Effective use of the concept entails a two tier approach to procurement. An initial purchase order commits for the total quantity predicted from diagrammatic during functional design. For example, if ninety valve operators are believed to be needed for a magazine flooding system in an aircraft carrier, delivery for partial amounts per dates derived from MOZS are specified.

For each MOZ, the earliest required date for a valve operator is established in the initial purchase order as the delivery date for all valve operators within the zone. Thus, the supplier is able to commit for raw materials and tooling and start manufacture based on an order for ninety.

Terms in the initial purchase order advise the supplier

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5 The descriptions Of A, S, and AS materials are from "Product Oriented Material Management," The National Shipbuilding Research Program, June 1985. The AS material concept is also referred to as "Net Requirements" in Industrial Engineering Handbook by H.B. Maynard, Chapter 4, Inventory and Management Control.

that the total quantity specified is just for start-up and that the final quantity, to be given in a purchase order amendment, may vary plus or minus some nominal amount as a consequence of further design development. Additional terms advise that the purchase order revision will also specify deliveries in smaller lots to match just-in-time scheduling for zone/stage work packages (pallets). As the date for the earliest required valve operator in each MOZ was previously used, the purchase order amendment will grant the supplier a little more time for almost all valve operators.

Intermediate-frame planning, of course, encompasses the preparation of functional drawings. At the same time, with no less priority, it too leapfrogs ahead with its strong emphasis on accelerating definition of AS materials, and when necessary even initiating their procurement. The material information is grouped for just-in-time deliveries in an intermediate-frame sense, and simultaneously, in a way that facilitates later subdivision by detail designers for just-in-time deliveries in a small-frame sense.

2.4 TRANSITION PLANNING

Transition planning is unique to zone logic. Some regard it as the beginning of detail design efforts, but its importance justifies treatment as a distinctly separate function. Transition planning is the last opportunity to nail down significant operational, maintainability, and productivity features. Further, the completion of transition planning is a natural juncture for the transfer of planning responsibilities from a planning yard to an implementing yard.

Again, as discussed in Part 2.1, specialists match problem categories. Fortunately the transition stage requires the least expenditure of man-hours, but because of the breadth of knowledge and experience required, very experienced people should be employed. In the context of specialties, transition planners have to understand ship operational and maintenance matters and prospective implementing yards' manufacturing systems.

Transition experts use as their primary inputs, contract arrangement drawings, diagrammatic, and pallet lists. They:

- overlay distributive system diagrammatic on contract arrangements in order to show system paths and their relationships to each other,

- designate foundations that should be combined and/or integrated with hull structure, regardless of systems,

- designate the approximate positions of controls, valves, gages, light fixtures, ventilation outlets, etc., not already fixed on contract drawings, relative to important equipment and machinery so as to enhance their operation,

o designate space reservations for maintenance and routes for initial installation of machinery and equipment as well as for their removal and reinstallation during future overhauls,

0 designate requirements for extraordinary shoring, scaffolding, and temporary services,

0 refine and superimpose the pallet list (zones/areas/stages) geographically and by coding on the planning yard's design model, and

0 designate contingent pallets for CFM and LLTM that could cause significant disruption if delivery dates are missed.

In other words, transition planners per specialty create mechanisms for immediate control of detail design in order to insure operability, maintainability, and productivity, without themselves being involved in detail design. As planning yard transition documents should be incorporated in ShipAlt Records together with standard design details, they are powerful means for approval authorities to control detail design development by implementing yards and/or subcontractors.

The refined pallet lists, as superimposed on a design model, are for use by implementing yards to assign detail design responsibilities by zone/stage, regardless of systems represented, and to identify interfaces between pallets. [6]

A typical process, performed freehand before the introduction of computer aided design (CAD), includes superimposing pipe system diagrammatic on machinery arrangements. Typical transition planning objectives are to:

o provide the routing of all pipe and tubing systems

6 Because zone logic features more and better quality planning, no prospective implementing yard is likely to express need for traditional system arrangement and detail drawings with attendant BOMS. But any such requirement could easily be met. Interim products (pallets) are classified by system in addition to zone/stage/area. Since, transition planners identify the systems represented in pallets, and since all planning yards employ CAD systems, information grouped by system only can be readily provided.

(nothing should be left for field running as that would be work out of control),

- o organize pipes in parallel and as straight as possible within routes conceived during contract design (the goal is to facilitate a high percentage of straight pipe pieces during detail design),

- 0 specify system positions in pipe banks, by column and row numbers (to insure that pipes requiring frequent maintenance are most accessible),

- 0 where bent pipes are necessary, use only 45° and 90° as much as possible (to facilitate statistical control during pipe piece manufacturing),

- 0 as much as possible, show bends a sufficient distance away from likely pipe joints (pipe pieces planned to be bent, that are manufactured as straight pipe pieces with flanges, or other type couplings attached, and bent afterwards, are the second cheapest category after straight pipe pieces) , and

- 0 define the limits of outfit packaaes that are to be shop assembled, and designate the-pallets for joining one assembly to another, for fitting assemblies to structural blocks, or for landing them on board.

Transition planners should have little need to request approval to deviate from general and machinery arrangements, because they would probably be the same individuals who provided production engineering input during the large-frame planning stage. Their thinking, introduced during customer/planning yard negotiations a short time before, should already be in the arrangements mandated by ShipAlt Records. The changes, really adjustments, they might propose during transition planning would for the most part be of limited scope and as consequences of functional drawing and MLS developments.

With CAD there is some risk that designers will continue to use the developing design model without pausing to record the end of the transition stage. That is, they could further manipulate what is in the computer for further design development without making a record of what transition planners imposed. Having access to the transition planning afterwards is obviously important for discussions that could come up during and following detail design. Having files of transition planning from past modernization efforts, is also important because they could be applied to future projects by adaptation and because they are needed for teaching transition planning.

2.5 SMALL-FRAME PLANNING

Planning yard people should understand the final planning stage that normally would be assigned to an implementing yard. The entire effort, from the start of large-frame planning to the delivery of a modernized ship, has to be regarded as part of a single manufacturing system in which design is a true aspect of planning. Production engineers and designers at all levels, in both planning yards and implementing yards, should be the recipients of feedback from completed work packages as shown in Figure 1-7. All are obligated to analyze results and analysis is greatly facilitated when cost/schedule returns are per types of interim products, that is, per rationalized work flows.

Proposed changes in work methods or design details that may benefit a particular stage in a particular work flow, also have to be evaluated for their impact on the entire manufacturing system. Each planning yard functionary, therefore, should understand the entire process at least within the context of an assigned specialty.

Also, the transfer of responsibilities from a planning yard to an implementing yard at the end of a transition stage is not always practical nor, in some instances, desirable. For example, if the proper operation of a complex weapons control space is very dependent on the exact locations of all equipment and fittings, the planning yard may have to perform detail design as a customer imposed condition even before an implementing yard is designated.

Transfers of planning responsibilities do not have to be made at the same time for each specialty, nor even for different groups of ShipAlts within a specialty. What should be transferred and when it is transferred should be the consequence of customer/planning yard/implementing yard negotiations. Additional factors to be considered include time remaining before a ship availability starts, unique expertise, and the planning (including design) workloads in both the planning yard and in the designated implementing yard. Regardless of how the remaining planning activity is assigned, that which is transferred and when it is transferred should be the consequence of a formal transfer meeting and a written transfer agreement that includes the customer's acknowledgement. The customer would have to make commensurate funding adjustments.

Thus, for ideal grouping of information to support zone logic, planning yard people have to understand the application of a PWBS for a manufacturing process, starting with review of the Ship Alteration and Repair List (SARP), or such other authorizing document, through test and operation (sea triaik) . A typical pwbs, modeled to include rip out and installation of fittings, is shown in Figure 2-4. Planning yard people would have to also understand how the same logic is employed for structural and painting work in order to plan for integrated structural, fitting, and painting work.[7]

Planning yard production engineers, until relieved by implementing yard production engineers, should lead designers in a process that may be characterized as continually assessing, refining, and regrouping available information. The process should progress, as a baton passed in a relay race, when implementing yard production engineers and designers take over until the information is sufficient and its grouping is ideal, for rationalized work flows.

A tremendous advantage that stems from specialization, as described in Part 2.1, is that the degree of detailed information and the way it is grouped does not have to be the same for each specialty. A zone technology work package for complex electrical/electronics work to be accomplished in a specific zone during a specific stage, or even in a series of stages, may consist of an 8 1/2" by 11" booklet made up of a cover sheet and a number of distinct sections as shown in Figure 2-5. In contrast, a work package for piping renewals for all systems in a group of contiguous tanks, can consist of one composite drawing that is overlaid and coded for zone/stage/area control. The composite would also feature a material list that is divided to match the planned implementation of work.[8]

Regardless of whether booklets or composites alone are used, all systems, including tubing, should be included. Exceptions should be limited to short runs of lighting circuit cable and short lengths of tubing in the vicinities of gages. Allowing systems to be field run is the same as giving away control.

Initially, booklets like that described in Figure 2-5 are

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7 A PWBS for ship repair was first proposed in "Modern Ship Repair Technology Applied to Naval Vessels," by J.H. Shoemaker, Norfolk Naval Shipyard, 1982. This is analogous to integrated hull construction, outfitting, and painting as employed by the most effective shipyards for ship construction, as described in Ship Production, by R.L. Storch, C.P. Hammon and H.M. Bunch, Cornell Maritime Press, 1988.

8 "Unit Work Guide for Zone Outfitting in Repair and Overhaul," by S. Kjerulf, Journal of Ship Production, May 1987, pp. 95-110.

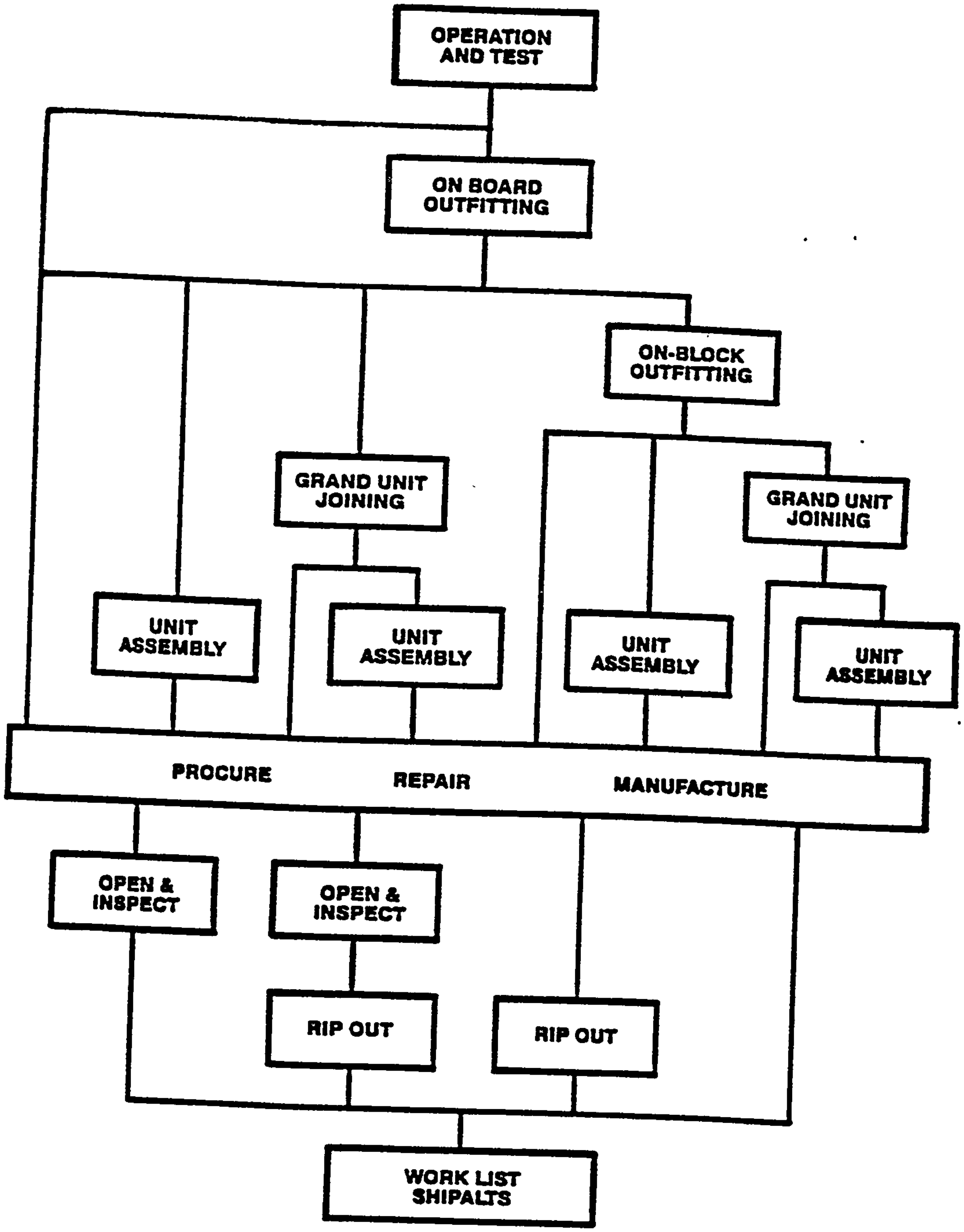

FIGURE 2-4a: Typical work flows by problem area for ship modernization.

PLANS LEVEL	MFG LEVEL	PRODUCT ASPECTS: ZONE	PRODUCT ASPECTS: PROBLEM AREA	PRODUCT ASPECTS: STAGE
1	9	SHIP	MACHINERY; DECK; ACCOMMODATION; ELECTRICAL/ ELECTRONICS	OPERATION AND TEST
2	8	ONBOARD DIVISION; NIL	SIMILAR WORK IN SMALL VOL/ SPECIALTY; SIMILAR WORK IN LARGE VOL/ SPECIALTY; SIMILAR HIGH SKILL WORK/ SPECIALTY	INSULATING / NIL WELDING / NIL LIGHT WEIGHT FITTING INSULATING / NIL WELDING / NIL HEAVY WEIGHT FITTING
3	7	BLOCK NIL; NIL	COMPONENTS IN A LARGE QUANTITY/ SPECIALTY; COMPONENTS IN A SMALL QUANTITY/ SPECIALTY	WELDING / NIL ON-DECK FITTING INSULATING / NIL WELDING / NIL ON-CEILING FITTING
4	6	UNIT; NIL	LARGE SIZE UNIT; NIL	WELDING / NIL JOINING
5	5	UNIT	LARGE SIZE UNIT; SMALL SIZE UNIT	WELDING / NIL ASSEMBLY
6	4	COMPONENT	SCRAPING; OVERHAULING; IN-HOUSE MANUFACT; OUTSIDE MANUFACT; PURCHASING	PALLETIZING MANU. / NIL MAT'L PREP / NIL
7	3	ONBOARD DIVISION; YARD SHOP	SIMILAR WORK IN SMALL VOL/ SPECIALTY; SIMILAR WORK IN LARGE VOL/ SPECIALTY; SIMILAR HIGH SKILL WORK/ SPECIALTY	REFINE PLANNING INSPECT AND REPORT DISASSEMBLY
8	2	ONBOARD DIVISION; NIL	SIMILAR WORK IN SMALL VOL/ SPECIALTY; SIMILAR WORK IN LARGE VOL/ SPECIALTY; SIMILAR HIGH SKILL WORK/ SPECIALTY	SORTING DISASSEMBLY
9	1	SHIP	MACHINERY; DECK; ACCOMMODATION; ELECTRICAL/ ELECTRONICS	PLANNING (INCLUDES DESIGN) PRE-ARR. INSP. / NIL OVERHAUL WORK LIST SHIPALTS

FIGURE 2-4b: Typical manufacturing levels and product aspects for ship modernization.

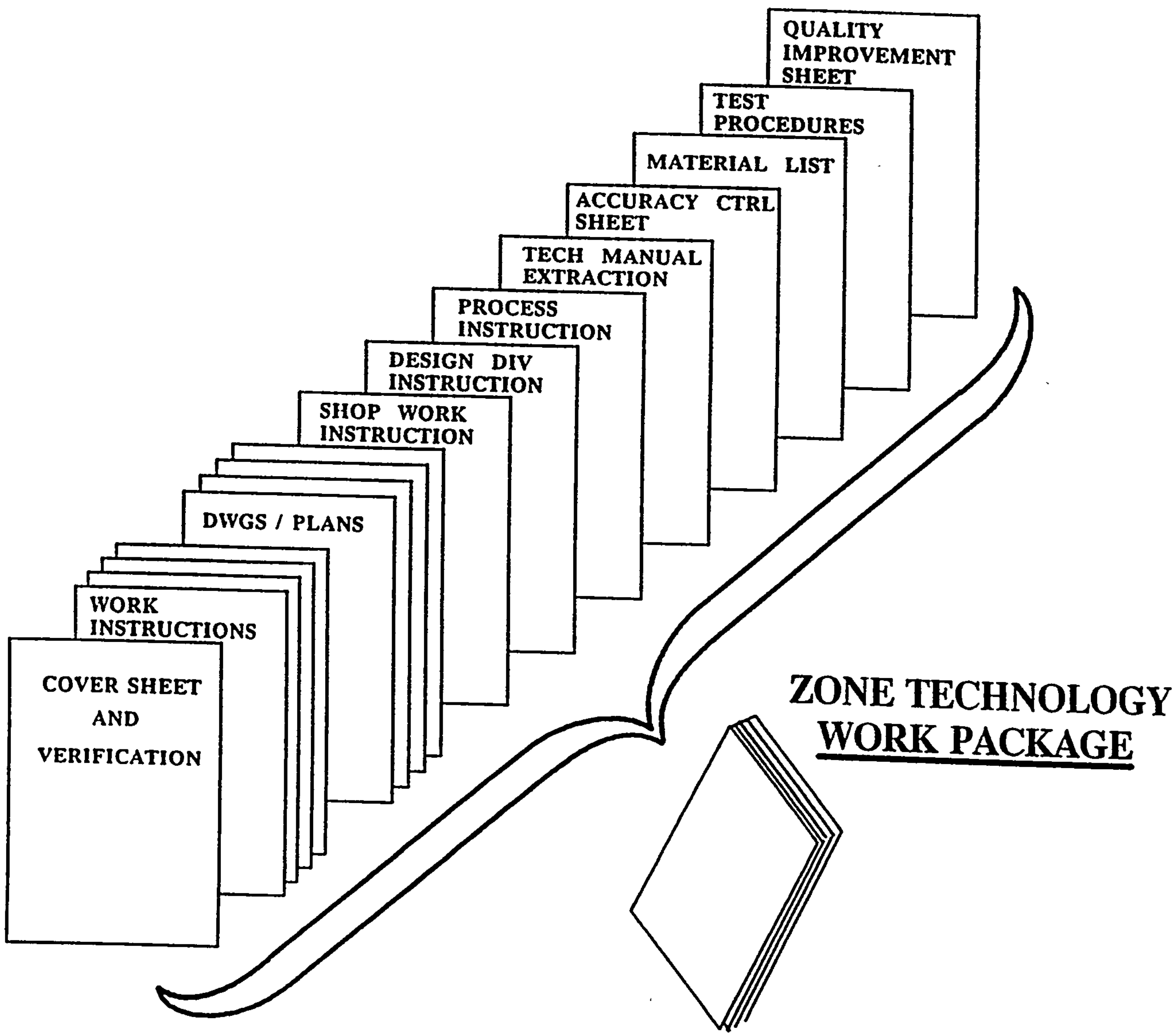

FIGURE 2-5: A work instruction booklet could incorporate a number of pallets. (Provided by Philadelphia Naval Shipyard)

sometimes justified only until workers who, in the past were required to apply only their craft expertise, have developed expertise per product. How to simplify work instructions without losing control, should be continuously analyzed following implementation of work.

Even ShipAlt work in a space that is moderately complex and requiring CPM and/or LLTM, could be controlled by a single composite drawing having overlaid zones accompanied by codes that identify stages and problem areas. The material list could be conventionally prepared but would have to be supplemented by two columns. One would identify the pallet destination(s) for each line of material (instructions for material marshaling people). The second would identify contingent pallets for CPM and/or LLTM. This latter requirement is very important.

In effect, contingent pallets are warnings to the customer, planning yard, and implementing yard people concerned with events leading to material palletizing. Because productivity indicators are different for something that could have been fitted in a shop assembled unit or landed in a relatively accessible space on board, as compared to later landing the same item in what has become a relatively inaccessible space on board, the required increase in the man-hour budget and the shift in the man-hour distribution due to late delivery is known beforehand. In other words the impact on productivity and schedules are preassessed, mostly analytically determined in the absence of emotional argument, and very clear.

Some people who are responsible for timely delivery of CFM are not likely to be enthused about the contingent pallet concept “because it gives claims advantage to implementing yards." They should be made to understand that all material procurement matters, no matter how remote or when initiated, become a de facto part of an implementing yard's manufacturing system. The use of rationalized work flows is for the purpose of achieving effective analyses so that problems and the extents of their impacts are identified. Regardless of who is responsible, the Navy's best interest is always served when the impacts of late materials are accurately identified and assessed. Otherwise, attempts to improve material support activities will be futile.

Detail designers also have to be given production engineering guidance about what different fittings impose the same type of work so that they may be incorporated on the zone/stage composite regardless of systems represented. An example of work that should be included on the same composite is shown below. Each bullet or heading item if there are no bullets would represent an individual composite. Similar lists should be prepared separately for each specialty.

Tagging

- o All electrical/electronic equipment, furniture, pipe, ventilation duct, lightweight foundations to be removed.
- o All heavy foundations, stanchions, beneath deck stiffeners to be removed. ,
- 0 All electric cable to be removed.

Removing Small Fittings

- o Generally everything limited by weight and length that one worker can remove safely (includes electrical/electronic equipment, furniture, pipe, ventilation duct, and lightweight foundations) .
- 0 Electric cable.

Installing Shoring & Scaffolding

Removing Large Fittings

- o Generally everything for which more than one worker is required for safe 'removal (includes electrical/electronic equipment, furniture, large diameter pipe, ventilation duct of extraordinary length, heavy foundations and beneath deck stiffeners) .

Cleaning & Holding-Coat (primer) Painting

Laying Out Reference Lines and Points (for all systems)

Fitting Large Components

- o Generally everything for which more than one worker is required for safe installation (includes . electrical/electronic equipment, large diameter pipe, ventilation duct of extraordinary length, heavy weight foundations and beneath deck stiffeners) .

Inspecting (for compliance with dimensional tolerances and weld quality).

Removing Shoring & Scaffolding

Installing Small Fittings (small diameter pipe, ventilation ducts, electric cable lengths, etc.)

Connecting Electric Cable Ends

Testing (initial phase)

Painting (all but finish coat)

Testing (final phase)

Cleaning, Painting (final coat) & Labeling

How the fis are grouped should be based upon the equivalence of work. They should not be grouped to reflect how production shops are organized unless the shops themselves are product oriented. Often, the separations are influenced by work volume, access to work, skills available, and materials available. The grouping of information to facilitate productivity should be used as the basis for developing product trades, individuals or teams having all skills necessary to produce a class of interim products regardless of the systems represented. In other words, people should be grouped to match a PWBS. [9] 10

As materials are being further defined on Material Lists for Fittings (MLFs) to correspond with pallets, the same very important computer program described in Part 2.3, continues to sort and carefully compare in order to provide answers to the same two questions as before:

- o Are any materials now being defined for the first time?
- o If not, do quantities now exceed those recorded in the contract design material budget and in MLS?

The objectives remain the same, to confirm or adjust man-hour budgets and schedules.

During all but the last stage, planning should be strategic in nature. But before the completion of a zone/stage work package (about six weeks before each is scheduled for issue), planning should be tactical in nature and preferably provided by the foremen who will be in charge of implementation, working with specialist counterparts in design. The foremen provide sequences for rip out and reinstallation, subdivisions in the material list which each equate to about forty man-hours, reference lines and points needed for assembly work, etc.

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9 The name product trade was introduced by Philadelphia Naval Shipyard. People were taken from traditional shops and assigned to newly created shop organizations that are specialized per product. See Figure 3 of '`Strategizing and Executing the Implementation and Utilization of Zone Technology at Philadelphia Naval Shipyard," by L.D. Burrill, B.S. Munro, M.S. O'Hare, and K. Baba, Journal of Ship Production, August 1990, p. 166.

10 How production can be organized to match a PWBS is shown in Figure 1 of "Productivity: How to Organize the Management and How to Manage the Organization," by L.D. Chirillo, Naval EnGineers Journal, November **1930**, p. 28.

The process of data reduction which started during large-frame planning and which is thus far described through pallet definition, is still not complete. In traditional organizations what remains, the detail planning for pipe pieces and components other than pipe pieces, is regarded as part of production. Detailing for the manufacture of pipe pieces in pipe shops and mold loft operations for structural work, are examples. Regardless of where performed, what should be understood in planning yards as well as in implementing yards is that such activities are a continuation of the planning process shown in Figure 1-5.

Zone logic, which uniquely provides for systematic data reduction from large-frame to small-frame focus, also identifies arbitrary restraints that prevent the full exploitation of CAD facilities. For example, the planning process shown in Figure 1-5 can easily continue in a planning yard until it produces the data, such as, sketches, tables, printouts, material lists, and even NC code required for manufacturing components such as pipe pieces, ventilation duct sections, precut electric cable lengths, distributive system supports, foundations, ladders, and walkway sections.

If CAD systems are are generally available and compatible, the planning yard produced design model can be readily transferred to an implementing yard after any planning stage. Similarly, because CAD terminals can be made available in shops, a yard planning department can readily defer the detailing of components, or even the preparation of some zone/stage work packages, to yard shops. With the same ease, a yard planning department can assign such work to qualified subcontractors.

Assignment of detail design must of course first consider qualifications. But among the qualifiers, assignment should be based upon their workloads. Within a shipyard, if planning department people are busy and shop field engineers and their assistants are not, the work should be assigned to shops . If the reverse is true the work should be retained by the planning department. If both groups are busy the work should be assigned to a subcontractor or to the planning yard, if it needs work. Regardless of where the work is performed, the transition documents, a file of flexible standards, and a yard's PWBS provide unprecedented control of whomever does pallet and component detail designs. With feW eXCeptiOnS, pipe pieces, for example, must conform with the pipe piece families for which a yard's pipe shop is organized. The simple problem area code that detail designers are required to understand and assign for each' pipe piece, ensures that they are always alert for opportunities to increase the percentages of straight and other low cost pipe pieces. The same logic applies to all detail design work.

ince only completed components, including those to be overhauled or modified, appear as line items in MLFs and the materials from which they are assembled appear in MLPs and MLCS, the MLF/MLP and MLF/MLC relationships are those of structured material lists. MLP and MLC represent the last division of information in the planning process, shown in Figure 1-5, after which, the very important computer program continues to sort, compare and ask:

- o Are any materials now being defined for the first time?
- o If not, do quantities now exceed those recorded in the contract design material budget, in MLS, and/or in MLF?

The objectives are to again confirm or adjust man-hour budgets and schedules.

As envisioned by planning yard production engineers at the very start, work associated with each MLP and MLC is a pallet which also has zone/stage/area classifications. But, as long as pallet completion dates are met, a shop manager working only with problem area classifications, can fully exploit GT for internal shop operations independent of how GT is exploited elsewhere. This permits just-in-time batch fabrication or overhaul of different components, of varying designs required in different quantities, on rationalized work flows. 11

In addition, pallet required dates give shop managers the weekly sequence for completed components. During system-by-system operations, shop managers are left relatively uninformed about what component is required next. Usually they are told that many components for one system are required by a date scheduled for start of system assembly. They are not told that the work will continue for many months and that certain components are not required until late in the process.

2.6 SUMMARY

The growing complexity of modern warships is forcing a

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11 The process, which is further described for pipe piece production in "Pipe Piece Family Manufacturing", The National Shipbuilding Research Program, March 1982, is also applicable for the production of other components, such as structural parts, foundations, ventilation duct pieces, ladders, and walkway sections.

shift in dependence away from knowledge vested only in experienced craftsmen whose skills are channeled only for work on specific systems, to more and better quality planning that is focused on constant development of an entire manufacturing system. Specialists in both planning and production are now required to idealize interim products for their production on rationalized work flows according to GT logic. Because different regions of a ship are very different from each other, associated problems are different. Thus for example, different specialists are required for an electrical/electronics region as compared for those needed for a machinery region.

The specialists function in tiered planning stages without regard to whether they are located in a planning yard or in an implementing yard. The stages are:

- large-frame planning which includes contract design and a unique expression of a strategy which is a preview of required interim products,

- intermediate-frame planning which features functional drawings that are tentatively arranged and divided in order to jump start material ordering,

- transition planning, a quickly applied process wherein boundaries of interim products and operability, maintainability, and producibility features are incorporated by specialists, so as to control detail design development, and

- small-frame planning wherein detail design is performed as needed to produce parts, subassemblies, and assemblies regardless of the portions of functional systems incorporated.

The planning process is one of constantly refining and subdividing data until the descriptions and material requirements are sufficient for production on rationalized work flows. Throughout, top priority is given to comparing material requirements to what has been predicted before, because required man-hours are linked to material. Thus, constant assessment of required materials is means to constantly verify or adjust man-hour budgets and schedules.

3.0 RECOMMENDED CHANGES TO THE FMP MANUAL

While the Fleet Modernization Program Management and Operations Manual does not preclude the use of zone logic, it offers no specific encouragement or instructions. The following changes to the January 1985 edition (with Change 7 dated November 1988) would improve this situation:

3.1 VOLUME 1 Section 1

Subsection 1-2 Background

Add a fourth bullet item,

"0 Improving implementing yards' manufacturing systems."

Subsection 1-3.3.1 Drawing Preparation

After 'Isystem drawings," add "composite drawings per type of work,"

3.2 VOLUME 1 Section 2

Subsection 2-2.3 Planning Yard Responsibilities

In first bullet item after " . . and development." add "Acting as surrogate Overhaul Yards for required production engineering input until Overhaul Yards are designated.lt

Add a new subsection:

"2-2.8 Overhaul Yard Responsibilities

- o Exploiting the opportunities during performance of SHIPALTS to improve the manufacturing system."

3.3 VOLUME 1 Section 3

Subsection 3-1.1 Background

In the first sentence delete "proper advance planning," and substitute "a production engineered strategy before basic design starts,"

3.4 VOLUME 1 Section 4

Subsection 4-2.4 Planning Yard Responsibilities

In the third bullet item, after ". ..the cognizant SLM/PM" add "land in the context of a production-engineered implementation strategy”

In the fourteenth bullet item, after “...the installing activity” add “with information grouped as required by the installing activity”

Between the sixteenth and seventeenth bullet items add:

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the Headquarters System Command”

Following the very last bullet item add:

"• Constantly updating the design model with information obtained during shipchecks, with the design details incorporated in SIDS, and with as-built details obtained during evaluations of how the production processes performed.”

Subsection 4-2.4.2 Configuration Control

Between the third and fourth bullet items add:

"o Planning Yards will provide arrangement drawings for all distributive systems, that is, nothing is to be field run from diagrammatic except very short lengths of tubing and small-diameter electric cable”

Subsection 4-2.4.3.1 Contractor Responsibilities

In the second paragraph after “ . . .of engineering drawings,” add “material lists,”

Add a new subsection:

"4-2.4.6 Productivity Control

Planning Yards will provide on SIDS, counts of certain items to facilitate productivity analyses, such as: number of separate fittings, number of all pipe pieces, average pipe piece length, number of straight pipe pieces, number of pipe pieces that can be fabricated as straight pipe pieces and bent in the final work stage, number of pipe pieces having other that 90° and 45° bends, number of fittings to be assembled in shops as outfit modules, number of fittings to be assembled on block, number of fittings to be assembled on board, ratio of mock or loose-flange pipe pieces relative to total number of pipe pieces, total footage of all electric cable runs, footage of electric cable pulled on block, footage of electric cabled pulled on board, total. number of electric cable ends to be connected, number of electric cable ends connected on block, and number of electric cable ends connected on board.”

Subsection 4-6 ShipAlt Installation Drawings

In the second paragraph after “system drawings,” add “composite drawings per type of work,”

Subsection 4-6.2.1 Shipchecks

Add after the second paragraph: “The Planning Yard will constantly update the design model with information obtained during shipchecks and obtained during evaluations of how the production processes performed.”

Subsection 4-6.2.2 Drawing Development

In the first paragraph, following “...testing and installing” add "per a production engineered implementation strategy. Pallet codes to designate assembly work on an outfit module, on block or on board, shall be shown for each material itern. The number of separate parts should be minimized. Drawings are to provide for integrated structural, outfitting and painting work anticipating assembly in shops as much as possible. Parts, particularly pipe pieces, are to be coded in order to designate the problems inherent in their manufacture, computer sorting, and just-in-time manufacture per Group Technology logic. To the maximum extent possible, the weights and overall lengths of parts that are designated for fitting on board are to be limited to what one worker can handle safely."

Subsection 4-6.2.3 Procurement Specifications

Add the following as a second paragraph:
"The Planning Yard will place initial purchase orders for certain materials based on information available from functional diagrammatic in order to allow suppliers more time for obtaining raw materials and for setting up tooling.”

Subsection 4-8 Liaison Action Record

At the end of the last sentence add: “The LAR will also be used to document the mutually agreed upon transfer of outstanding detail design activities from a Planning Yard to an Overhaul Yard.”

3.5 VOLUME 1 Section 5

Subsection 5-1.2 Policy

Add a second paragraph as follows:
"The estimated man-days shall be related to material and statistically determined based upon how Overhaul Yards

normally perform, that is, in terms of mean values and standard deviations. Thus initially estimated man-days will be primarily derived from the initial material budget. Intermediate estimated man-days will be primarily derived from material lists that accompany functional SIDS such as diagrammatic, and the final, or detailed estimated man-days will be obtained from the material lists which accompany detail drawings."

3.6 VOLUME 1 Section 6

Subsection 6-1.1.2 Overall Responsibilities

Following "...provided in Subsection 6-1.4." add "No financial management responsibility shall detract from the safest and most productive way to organize and implement ShipAlt work. For example, man-day costs that are collected by type of work performed for more than one ShipAlt, may be prorated among ShipAlts in accordance with any scheme that is statistically valid."

Subsection 6-6.6.1 NavShipYd Review Estimates

In the first paragraph delete the last sentence and substitute: "The intent is to establish a system in which the interests of all activities are considered with particular emphasis on fulfilling ShipAlt functional requirements while structuring an approach to work which enables Overhaul Yards to simultaneously improve their manufacturing systems. The intent includes solving problems through arms length negotiation, so as to free each party to develop, propose, and evaluate strategies in pursuit of accomplishment of a common goal."

3.7 VOLUME 1 Section 7

Subsection 7-1.2 Background

Delete the first bullet item and substitute

"o Assessing all material requirements for each ShipAlt during basic design, refining all material requirements during functional design, and exactly defining all material requirements during detail design"

Add the following as a fifth bullet item:

"o Specifying just-in-time delivery dates."

Subsection 7-1.3 Policies

Delete existing paragraph e. and substitute

e. All material requirements will be assessed during basic design by (1) precise identification and quantities, (2) precise identification and estimated quantities, and/or (3) material classes and estimated quantities. All material requirements will be further defined during functional design and exactly defined during detail design. These requirements must be formally documented in accordance with references (i) through (k)."

In paragraph i. following "... availability start date" insert "or per a just-in-time delivery date specified by an Overhaul Yard."

3.8 ACRONYMS

Add the following:

MLS	Material List per System
MLF	Material List of Fittings
MLP	Material List per Pipe Piece
MLC	Material List per Component Other than a Pipe Piece
PPFM	Pipe Piece Family Manufacturing
PWBS	Product Work Breakdown Structure

3.9 GLOSSARY

Add the following:

Area - See Problem Area.

Design Model - A collection of data, in any form, that represents a ship as it actually exists.

Field Run - The practice of determining final locations and design details as work is being implemented. It is work out of management's control.

Group Technology - The logical arrangement and sequence of all facets of company operation in order to bring the benefits of mass production to high variety, mixed quantity production.

Interim Product - A discrete element identified as an objective in a work package. It is a part, subassembly, zone, system, etc., that has been transformed by the application of work. The transformation can be manifested by physical change or by change in circumstances, for example, change of an untested piping system to a tested system.

Pallet - A definite increment of work with allocated resources (information, labor, and materials) needed to produce a defined interim product.

Pipe Piece Family Manufacturing - The classification of pipe pieces into groups having design or manufacturing attributes which are sufficiently similar to make batch manufacturing practical. It employs Group Technology logic.

Problem Area - A division of work into similar, repeatable work processes. It is a classification of interim products using Group Technology logic.

Product Aspects - System and Zone which are characterizations of a ship design, and Problem Area and Stage which are characterizations of a manufacturing system. If the word “zone” is omitted, the three remaining product aspects are in the context of a traditional system work breakdown structure. If the word "systemil is omitted the three remaining product aspects are in the context of a modern product work breakdown structure.

Product Work Breakdown Structure - A vision of a sequence of interim products to be ripped out or installed for constructing, modernizing, or overhauling a ship.

Work Flow, Real - Rationalized organization of work wherein materials being processed move and workers are at a fixed work site, for example, as for automobile production.

Work Flow, Virtual - Rationalized organization of work wherein materials being processed are stationary and workers move from site to site, for example, as when cleaning ships’ ballast tanks.

Work Instruction - A collection of just the data needed to produce an interim product. Dependent upon an interim product’s complexity, a work instruction, can consist of an 8 l/2i’ X1l" booklet containing a composite drawing, material . list, process instructions, safety and test procedures, etc.

Zone/Stage/Area - The three product aspects that are . utilized for organizing real and virtual work flows. “Zone” refers to geographical divisions that incorporate an interim product required, "stage" refers to a division in time that establishes when an interim product is required relative to others, and “Area” designates the work flow, that is, the resources needed to produce an interim product.

3.10 VOLUME 2 MANAGEMENT AND OPERATIONS MANUAL (SL720-m-MAN-010)

1. Scope

In Subsection 1.3 add

"f. Implementation Strategy

3. Requirements

In Subsection 3.2 Delete the first sentence and substitute "Each activity shall designate qualified production engineers and designers to act as liaison planning representatives ."

4. Changes, Waivers and Deviations

In Subsection 4.2.d. add the following sentence: "Valid objectives include improvement in productivity as well as in operability and maintainability."

3.11 VOLUME 2 TECHNICAL SPECIFICATION (9090-500B)

Subsection 3.2.1 Planning Yards

Following " . ..to the Planning Yard include" add "imposition of a generic, basic implementation strategy, material definition, 't

Subsection 3.3.4.3 NAVAIR/SPAWAR/OTHER (Technical and Logistics) Approval

Following " . ..personnel safety, " add "maintainability,"

3.12 VOLUME 2 TECHNICAL SPECIFICATION (9090-600) dated 4 September 1984

Subsection 3.2.1 ShipAlt Drawings

After " . . and detail drawings, " add "work instruction drawings,"

Add the following paragraph:

"l. Drawings shall contain codes which indicate manufacturing problem areas for parts and for assemblies."

Subsection 3.3.1 Planning Yard

After " . ..engineering design agent" insert "and the production engineering surrogate"

Add the following three paragraphs:

"g Initially grouping design information in the context of basic, generic implementation strategies and afterwards refining the groupings per mutual agreements with designated implementing yards.

h. Recommending to NavSea Engineering Directorates the most optimum combinations of ShipAlts, including partial ShipAlts, that should be incorporated in integrated design drawings.

i. Recommending to NavSea Engineering Directorates rearrangements and/or reconfiguration to existing systems, compartments or spaces that should be made during ShipAlt implementation that would significantly improve operability, maintainability, and/or productivity."

Subsection 3.4.I.l

After '[1]. ..departure to" add "facilitate material and production control,"

Subsection 3.5.3 Drawing Types

Add "g. Work Instruction Drawings (see 3.5.12)"

Subsection 3.5.5 Parts/Material/Equipment Lists

In paragraph b. after "1 . ..for ordering material" insert "not already ordered"

Subsection 3.5.5.2

Add the following three paragraphs:

"l. Problem Area. A code which identifies the set of problems inherent in manufacture (Group Technology) for those items to be custom manufactured shall be shown in this column.

m. Pallet Identification. A code which identifies the pallet destination for each material item shall be shown in this column.

n. The designator AS shall be shown in this column for each material item that is classed as Allocated Stock."

Subsection 3.5.5.3 Equipment Lists

Add the following paragraph:

"k. Pallet Identification. A code which identifies the pallet destination for each equipment shall be shown in this column.”

Subsection 3.5.6.2 List of Material.

In paragraph a. after “and APL number (see 3.5.5.2)” add “, and a code which identifies the pallet destination of each material item.”

Subsection 3.5.6.3 General Content.

In paragraph a. delete “weighing fifty pounds or more. For machinery equipments weighing less than fifty pounds, complete foundation/mounting details are required if the foundation is fabricated or if the mounting requirements are critical, unusual or complex.”

Subsection 3.5.7.2 List of Material.

After “ . ..top of the material list downt" insert "to facilitate material take offs. A separate list of material shall be sequenced in the order that materials are to be installed to facilitate production control.”

In paragraph e. after “and APL number (see 3.5.5.2)” add “, and a code which identifies the pallet destination of each material item.”

Subsection 3.5.7.3 General Content

Delete paragraph b. and c. and substitute:

“b. Piping drawings. All piping installation drawings shall be complete arrangement and detail drawings. Only short runs of small diameter tubing shall be excepted. Single-line representation for piping up to 1 1/2 inches I.P.S. (Iron Pipe Size) may be used. Piping greater than 1 1/2 inches I.P.S. shall be represented by two parallel lines that are at a distance apart corresponding to scaled dimensions of outside diameters. All details of pipe, valve, hanger and fitting configuration as well as key dimensions to locate pipes, components, hangers and pipe bends whose locations are critical due to pipe stress, space restraints, productivity considerations, etc. Preferably tolerances that are derived from statistical analysis of accuracy normally achieved should be employed. Otherwise a tolerance of plus or minus 1/2 inch shall be applied to the dimensions and shall be so stated on drawings. Where composites are employed piping installation drawings may be integrated with duct installation drawings.

c. HVAC drawings. All duct installation drawings shall be complete arrangement and detail drawings which show all fittings and plenums. Duct shall be represented by two parallel lines that are at a distance apart corresponding to scaled widths and heights. Key dimensions and all critical hangers, fittings, etc. shall be detailed on the drawings. Where composites are employed duct installation drawings may be integrated with piping installation drawings.

Subsection 3.5.8.2 List of Material.

In paragraph a. after “and APL number (see 3.5.5.2)" add " and a code which identifies the pallet destination of each material item.”

Subsection 3.5.8.3 General Content

In paragraph b. after “ . ..all material requirements” insert "including information required for procuring precut cable lengths,"

At the end of paragraph b. add a new sentence as follows: "Composite arrangement drawings used for work instructions shall show pallet designations for each equipment and each material item.”

In paragrph c. following ‘[1]

which address work of one type regardless of systems represented, may also be used as integrated design drawings."

Subsection 4.1.4 Drawing Control Procedures.

Delete paragraph c. and substitute

Ilc. Preparation of drawings and material ordering data in the same sequence specified for implementation of work in a production engineered ShipAlt implementation strategy.11

Subsection 4.2 Nonconforming Data Items.

Add the following new subsection:

‘!4.2.2.4 Engineering/Technical Quality Indicator. With defects defined as any engineering or technical matter that necessitates a change in material ordering data, the number of defects relative to the total number of material line items shall be maintained as a Planning Yard quality indicator .“

Subsection 6.3 Definitions.

Between Subsections 6.3.24 and 6.3.25 add the following definition:

“Design Model. Any collection of information which describes a ship including all its structure, equipment, fittings and arrangements. The design model may be incorporated in cabinet files of conventional drawings, in computer files, or in any combination thereof.”

4.0 THE BENEFITS OF COMBINING SHIPALTS: A SPREADSHEET APPLICATION

4.1 MOTIVATION

The identification of potential ShipAlts to be accomplished for a given-availability- is an iterative process. Often there can be considerable change in both the number and type of ShipAlts that are addressed from the earliest planning stages until the final work scope is chosen. Additionally, this uncertainty makes the development of meaningful cost estimates for various combinations of ShipAlts difficult to obtain. Consequently, a simple tool to monitor and help evaluate numerous combinations would be useful, both for Planning Yards throughout the planning" process and for Navy decision-makers, as they consider cost and operability tradeoffs.

4.2 SPREADSHEET TOOL DESCRIPTION

The development of a generic overhaul strategy for ship types has been described previously. In effect, this strategy provides a list of zone/stage pallets by specialty. In the context of this available generic strategy; ShipAlt designers can identify pallets impacted by potential ShipAlts very early in the planning process. In fact, one of the first tasks of the planning yard should be to identify these pallets associated with each ShipAlt. Once this has been accomplished, the information can be input to a spreadsheet matrix, which has the pallet list that forms the generic strategy on one axis, and the ShipAlts under consideration on the other axis, as shown in Table 4-1. The four specialties employed in this example are the likely ones for a naval auxiliary, including machinery (M) , deck (D), accommodations (A) and electrical/electronics (E/E). The row headings show there are three different ShipAlts under consideration. Thus , as multiple ShipAlts are considered and entered into the spreadsheet, a record of the pallets required is developed, and the potential synergistic benefit of performing combinations of two or more ShipAlts is identifed and computed.

4.3 SPREADSHEET OPERATION

After each ShipAlt has been analyzed only in enough detail to identify pallets required, data can be entered into the spreadsheet. A "l" input into the cell for a specific pallet and a specific ShipAlt indicates that a pallet is required to complete the ShipAlt. Cells for pallets not impacted by the ShipAlt have "o" entered. As additional ShipAlts are identified and the estimating process

ZONE	STAGE	SAR 1	SAR 2	SAR 3
M1	1			
	2			
M2	1			
	2			
	3			
M3	1			
	2			
	3			
M4	1			
	2			
M5	1			
	2			
M6	1			
	2			
M7	1			
M8	1			
	2			
M9	1			
	2			
M10	1			
	2			
	Total =			

ZONE	STAGE	SAR 1	SAR 2	SAR 3
D1	1			
	2			
D2	1			
	2			
D3	1			
D4	1			
	2			
	1			
	2			
	Total =			

TABLE 4-1a: Initial preadsheet input matrix

ZONE	STAGE	SAR 1	SAR 2	SAR 3
Al	1			
	2			
A2	1			
	2			
	3			
A3	1			
	2			
	3			
A4	1			
	2			
A5	1			
	2			
A6	1			
	2			
	3			
	Total =			

ZONE	STAGE	SAR 1	SAR 2	SAR 3
	4			
E/E7	1			
	2			
	3			
	Total =			

TABLE 4-lb: Initial spreadsheet input matrix

to the spreadsheet for additional columns reflecting the pallets impacted by these additional ShipAlts. Table 4-2 shows the spreadsheet with initial data (for three fictional ShipAlts) input. Note that the initial planning and design analysis is only to identify pallets by specialty involved in each ShipAlt. At any point in this process, the spreadsheet matrix can be screened to identify pallets that are impacted by more than one ShipAlt. This first output matrix is shown in Table 4-3. In the column labeled *zone/stage multiple impacts* in this matrix, a "1" appears in each cell in which more than one ShipAlt has an impact and a "0" in each cell in which one or no ShipAlt has an impact. Pallets having the potential for time or cost savings are thus clearly identified.

As the ShipAlt designers make more information available, estimates of work content (cost) per pallet, perhaps by estimating parametric material weight and multiplying by the appropriate productivity index, are obtained. This data can then be entered into appropriate cells in the spreadsheet. Since the ShipAlt designers are alerted to areas of potential synergistic cost savings per pallet, estimates of these savings can be made. This data can then be input into the spreadsheet to permit easy compilation of the total savings associated with zone/stage combination of ShipAlts. Simple manipulation of the spreadsheet permits evaluation of a number of different ShipAlt combinations for potential synergistic savings. Table 4-4 shows the spreadsheet into which data is entered as the design process has progressed. Now, man-hour estimates for ShipAlt work by pallet can be input. The estimated savings by combining work from different ShipAlts involving the same pallet can also be input into the appropriate cell in the spreadsheet. Table 4-5 is a final spreadsheet output, indicating all pallets impacted by all ShipAlts being considered, and also providing total cost estimates and synergistic cost savings.

The spreadsheets shown here were programmed using LOTUS 1-2-3. The procedure to set up such a spreadsheet matrix (using LOTUS 1-2-3 or any other spreadsheet software) is relatively straightforward.

ZONE	STAGE	SAR 1	***SAR 2***	SAR 3
Ml	1	1	***1***	1
	2	1	***1***	1
M2	1	1	0	1
	2	0	1	1
	3	1	0	1
M3	1	1	1	0
	2	1	1	0
		1	1	0
M4	:	1	0	1
	2	1	0	0
M5	1	1	1	1
	2	1	1	1
M6	1	0	0	0
	2	0	0	0
M7	1	1	1	1
M8	1	1	1	1
	2	1	1	1
M9	1	1	0	1
	2	1	1	1
M1O	1	1	0	0
	2	1	0	0
	Total =	***18***	12	13

ZONE	STAGE	SAR 1	SAR 2	***SAR 3***
D1	1	1	0	**1**
	2	1	0	***1***
D2	1	0	0	1
	2	0	0	1
D3	1	1	0	1
D4	1	***1***	0	**1**
	2	0		1
D5	1	0	:	0
	2	0	0	0
	Total =	4	0	7

TABLE 4-2a: Initial spreadsheet data input

ZONE	STAGE	SAR 1	SAR 2	SAR 3
Al	1	1	0	
			0	1:
A2	:	0;	0	1
	2	o	0	1
	3	0	0	1
A3	1		0	1
	2	1:	0	1
	3	0	0	1
A4	1	1	0	1
	2	1		
A5	1	1	0:	1:
	2	1	0	1
A6	1	0	0	1
	2	0	0	0
	3	1	0	1
	Total =	9	0	13

ZONE	STAGE	SAR 1	SAR 2	SAR 3
E/El	1	1	1	0
	2		0	1
	3	0:	0	0
E/E2	1	1	1	1
	2	0	1	1
	3	0	1	0
E/E3	1	1	0	
	2	1	0	1
E/E4	1	0	1	1
	2	0	1	0
E/Es	1	1	1	1
	2	0	1	1
E/E6	1	1	1	0
	2	1	1	1
	3	1	1	0
	4	1	1	
E/E7	1	1	1	1
	2		1	0
	3	1	1	0
	Total =	12	15	9

TABLE 4-2b: Initial spreadsheet data input

ZONE	STAGE	SAR 1	SAR 2	SAR 3	ZONE/STAGE MULTIPLE IMPACTS
Ml	1		1	1	1
	2	1	1	1	1
M2	1	1	0	1	1
	2	0	1	1	1
	3	1	0	1	1
M3	1	1	1	0	1
	2	1	1	0	1
	3	1	1	0	1
M4	1	1	0	1	1
	2	1	0	0	0
M5	1	1	1	1	1
	2	1	1	1	1
M6	1	0	0	0	
	2	0	0	0	0
M7		1		1	1
M8	1	1	1	1	1
	2	1	1	1	1
M9	1	1	0	1	1
	2	1	1	1	1
Ml 0	1	1	0	0	0
	2	1	0	0	0
	Total =	18	12	13	16

ZONE	STAGE	SAR 1	SAR 2	SAR 3	ZONE/STAGE MULTIPLE IMPACTS
D1	1	1	0	1	1
	2	1	0	1	1
D2	1	0	0	1	
	2	0	0		0
D3	1	1	0	1	1
D4	1	1	0	1	1
	2	0	0	1	0
D5	1	0	0	0	0
	2	0	0	0	0
	Total =	4	0	7	4

TABLE 4-3a: Initial spreadsheet output showing multiple impacts

ZONE	STAGE	SAR 1	SAR 2	SAR 3	ZONE/STAGE MULTIPLE IMPACTS
Al	1	1	0	1	1
	2	1	0	1	1
A2	1	0	0	1	0
	2	0	0	1	0
	3	0	0	1	0
A3	1	1	0	1	1
	2	1	0	1	1
	3	0	0	1	0
A4	1	1	0	1	1
	2	1	0	0	0
A5	1	1	0	1	1
	2	1	0	1	1
A6	1	0	0	1	0
	2	0	0	0	0
	3	1	0	1	1
	Total =	9	0	13	8

ZONE	STAGE	SAR 1	SAR 2	SAR 3	ZONE/STAGE MULTIPLE IMPACTS
E/El	1	1	1	0	1
	2	1	0	1	1
	3	0	0	0	0
E/E2	1	1	1	1	1
	2	0	1	1	1
	3	0	1	0	0
E/E3	1	1	0	0	0
	2	1	0	1	1
E/E4	1	0	1	1	1
	2	0	1	0	0
E/Es	1	1	1	1	1
	2	0	1	1	1
E/E6	1	1	1	0	1
	2	1	1	1	1
	3	1	1	0	1
	4	1	1	0	1
E/E7	1	1	1	1	1
	2	0	1	0	0
	3	1	1	0	1
	Total =	12	15	9	14

TABLE 4-3b: Initial spreadsheet output showing multiple impacts

ZONE	STAGE	ZONE/STAGE MULTIPLE IMPACTS	SAR 1 MANHOUR ESTIMATE	SAR 2 MANHOUR ESTIMATE	SAR 3 MANHoUR ESTIMATE	ESTIMATED MANHoUR SAVINGS
Ml	1	1				
	2	1				
M2	1	1				
	2	1				
	3	1				
M3	1	1				
	2	1				
	3	1				
M4	1	1				
	2	0				
MS		1				
	1	1				
M6	1	0				
	2	0				
M7	1	1				
Ma	1	1				
	2	1				
M9	1	1				
	2	1				
M1O	1	0				
	2	0				
	Total =	16				

ZONE	STAGE	ZONE/STAGE MULTIPLE IMPACTS	SAR 1 MANHOUR ESTIMATE	SAR 2 MANHOUR ESTIMATE	SAR 3 MANHouR ESTIMATE	ESTIMATED MANHouR SAVINGS
D1	1	1				
	2	1				
D2	1	0				
	2	0				
D3	1					
D4	1	1				
	2	0				
D5	1	0				
	2	0				
	Total =	4				

TABLE 4-4a: Spreadsheet matrix for entering man-hour estimates

ZONE	STAGE	ZONE/STAGE MULTIPLE IMPACTS	SAR 1 MANHOUR ESTIMATE	SAR 2 MANHOUR ESTIMATE	SAR 3 MANHOUR ESTIMATE	ESTIMATED MANHOUR SAVINGS
Al	1	1				
	2	1				
A2	1	0				
	2	0				
	3	0				
A3	1	1				
	2	1				
	3	0				
A4	1	1				
	2	0				
A5	1	1				
	2	1				
A 6	1	0				
	2	0				
	3	1				
	Total =	8				

ZONE	STAGE	ZONE/STAGE MULTIPLE IMPACTS	SAR 1 MANHOUR ESTIMATE	SAR 2 MANHOUR ESTIMATE	SAR 3 MANHOUR ESTIMATE	ESTIMATED MANHOUR SAVINGS
E/El	1	1				
	2	1				
	3	0				
E/E2	1	1				
	2	1				
	3	0				
E/E3	1	0				
	2	1				
E/E4	1	1				
	2	0				
E/ES	1	1				
	2	1				
E/E6	1	1				
	2	1				
	3	1				
	4	1				
E/E7	1	1				
	2	0				
	3	1				
	Total =	14				
OVERALL	TOTAL =	42				

TABLE 4-4b: Spreadsheet matrix for entering man-hour estimates

ZONE	STAGE	ZONE/STAGE MULTIPLE IMPACTS	SAR 1 MANHOUR ESTIMATE	SAR 2 MANHOUR ESTIMATE	SAR 3 MANHOUR ESTIMATE	ESTIMATED MANHOUR SAVINGS
Ml	1	1	35	53	87	
	2	1	66	46	53	71
M2	1	1	35	0	64	28
	2	1	0	25	34	0
	3	1	68	0	35	35
M3	1	1	76	78	0	33
	2	1	68	35	0	12
	3	1	46	84	0	42
M4	1	1	86	0	97	75
	2	0	56	0		0
M5	1	1	46	23	53	32
	2	1	46	26	68	57
M6	1	0	0	0	0	0
	2	0	0	0	0	0
M7	1	1	57	37	86	57
M8	1	1	86	26	54	46
	2	1	25	74	54	12
M9	1	1	[illegible]	0		0
	2	1	25	54	76	46
M10	1	0	75	0	o	0
	2	0	68	0	0	0
	Total =	16	1039	561	*848*	*580*

ZONE	STAGE	ZONE/STAGE MULTIPLE IMPACTS	SAR 1 MANHOUR ESTIMATE	*SAR 2* MANHOUR ESTIMATE	*SAR 3* MANHOUR ESTIMATE	ESTIMATED MANHOUR SAVINGS
D1	1	1	46	0	45	37
	2	1	46	0	68	26
D2	1	0	0	0	86	0
	2	0	0	0	34	0
D3	1	1	57	0	86	38
D4	1	1	86	0		46
	2	0	0	0	54	0
D5	1	0	0	0	o	0
	2	0	0	0	0	0
	Total =	4	*235*	0	*427*	147

TABLE 4-5a: Final spreadsheet matrix

ZONE	STAGE	ZONE/STAGE MULTIPLE IMPACTS	SAR 1 MANHOUR ESTIMATE	SAR 2 MANHOUR ESTIMATE	SAR 3 MANHOUR ESTIMATE	ESTIMATED MANHOUR SAVINGS
A1	1	1	46	0	63	33
	2	1	78	0	56	50
A2	1	0	0	0	64	0
	2	0	0	0	65	0
	3	0	0	0	26	0
A3	1	1	37	0	32	17
	2	1	54	0	34	25
	3	0	0	0	86	0
A4	1	1	31	0	65	22
	2	0	56	0	0	0
A5	1	1	46	0	45	0
	2	1	46	0	68	41
A6	1	0	0	0	86	0
	2	0	0	0	0	0
	3	1	46	0	68	33
	Total =	8	440	0	758	221

ZONE	STAGE	ZONE/STAGE MULTIPLE IMPACTS	SAR 1 MANHOUR ESTIMATE	SAR 2 MANHOUR ESTIMATE	SAR 3 MANHOUR ESTIMATE	ESTIMATED MANHOUR SAVINGS
E/E1	1	1	4	45	0	4
	2	1	46	0	68	39
	3	0	0	0	0	0
E/E2	1	1	75	75	86	43
	2	1	0	35	86	13
	3	0	0	76	0	0
E/E3	1	0	46	0	0	0
	2	1	36	0	68	31
E/E4	1	1	0	34	86	18
	2	0	0	32	0	0
E/E5	1	1	86	34	54	46
	2	1	0	43	54	0
E/E6	1	1	43	53	0	15
	2	1	75	36	76	46
	3	1	75	54	0	41
	4	1	75	34	0	24
E/E7	1	1	68	35	57	53
	2	0	0	87	0	0
	3	1	75	87	0	50
	Total =	14	704	760	635	423
OVERALL TOTALS =		42	2418	1321	2668	1371

TABLE 4-5b: Final spreadsheet matrix

5.0 RECOMMENDATIONS

5.1 IMPROVE THE MANUFACTURING SYSTEM

There is great need for OpNav and NavSea to recognize that a shipyard's ability to improve itself while implementing ShipAlt work is just as much a military requirement as upgrading weapons systems in warships. Fortunately, virtually all military and technical improvements can be achieved while simultaneously and manifestly providing for manufacturing system improvement.

OpNav should state, "A shipyard's ability to improve its manufacturing system during implementation of any work is a military requirement."

NavSea should state in The Fleet Modernization Program Management and Operations Manual, "Shipyards shall provide, for improvements in their manufacturing systems during ShipAlt implementation."

Significant improvement is dependent upon concerted ' application of all of the basic management functions, that is:

- o estimating,
- o planning (design is an aspect of planning) ,
- o scheduling,
- 0 implementing (both material marshaling and producing), and
- o evaluating.

Therefore, with particular emphasis on those who participate in developing contract requirements, a manufacturing system must be regarded as including all organizations that influence how shipyards perform. For ShipAlt work they include:

- o Ship Logistics Managers(SLMs)/Program Managers (PMs),
- o Type Commanders (TyComs),
- o Engineering Directorates (EDs), and
- o planning yards.

SLMs, PMs, TyComs, and EDs are customers. They should understand that their best interests are served when their military and technical requirements are formatted in a way that permits further refinement and eventual implementation per modern, zone oriented manufacturing technology.

Planning yards serve two masters. They function as agents of customers during their preparation of:

- o ShipAlt Records, that is, preliminary design activities that are sufficient for ShipAlt programming decisions, and

- o SIDs that have the effect of contract drawings.

And they serve implementing shipyards during their preparation of such other SIDs that are required.

OpNav should state, "Because contract design is part of the manufacturing system, SLMs/PMs, TyComs, and EDs, shall negotiate, preferably with implementing yards, but otherwise with planning yards acting as surrogates, for the purpose of incorporating effective implementation strategies in contract drawings."

5.2 DEVELOP GENERIC STRATEGIES PER SHIP CLASS

Zone/stage control of work combined with addressing each type of work separately (for example, light-fitting rip out and heavy-fitting rip out), are all that are needed to devise a very useful, generic alteration strategy by ship class. That part of a strategy that applies to a single specialty within one ship class, say for machinery spaces, since it is by type of work, will be similar to that required for another ship class. Thus, very much can be adapted from class to class by just taking into account the different compartmentation.

OpNav should authorize a special project for the purpose of developing generic strategies that planning yards should use to preview how zone oriented work is most likely to be implemented.

NavSea should direct planning yards to provide codes in their design models so that they can offer implementing yards a choice of information in zone/stage groups that match a generic strategy or in traditional system-by-system groups.

5.3 INSTITUTE ZONE ORIENTED DESIGN STAGES

Contract and functional design are distinct stages in a traditional design approach. Transition and work instruction design stages do not exist. Zone orientation features system-by-system expertise applied to functional matters and initial material definition, but it also relies on zone oriented expertise per regional specialty, particularly for detail design and exact material definition. As more than two thirds of design man-hours are spent on detail design, the corporate culture will change for the majority involved in ShipAlt design efforts.

The change will entail a culture shock for many who believe they have achieved security by commanding design aspects of a particular function. Their vision cannot be expected to include optimizing implementation of entire ShipAlts nor their roles as de facto participants in a manufacturing system which has the obligation to continually improve.

NavSea should provide special assistance to planning yards in the form of programs to indoctrinate designers in zone logic, to identify people who cannot make the transformation, and to provide such people with other work or early retirement.

NavSea should require planning yards to implement the four distinct zone logic design stages, including, contract, functional, transition, and work instruction.

5.4 ESTABLISH PRODUCTION ENGINEERING IN PLANNING YARDS

Although a generic strategy per a ship type would be available, each planning yard would still require its own production engineers. They would be required at first to adjust a generic strategy in the context of a particular set of ShipAlts authorized for simultaneous implementation. Until an implementing yard is designated, planning yard production engineers would have to refine their strategy as design progress makes more information available.

NavSea should require each planning yard to develop a production engineering capability for each specialty represented in the ship classes assigned to them. Each person so assigned should have keen understanding of ship operational, ship maintenance, and shipyard manufacturing system matters for the specialty assigned.

5.5 SHIFT TO PRODUCT ORIENTED MATERIAL MANAGEMENT

Since material is the only tangible, the most effective shipyard management systems control production through control of material. Consumed man-hours are reported per physical characteristic of the interim products completed and according to the problems they impose, for example, man-hours: per length of electric-cable pulled separately for large, medium and small diameters; per pipe pieces fabricated separately by pipe-piece family; and per weight of electronic work packages separately for shop assembly and for on board assembly.

Statistical analyses of man-hour cost returns identify how such work normally (mean values and standard deviations) performs and are the bases for man-hour budgeting and scheduling. When constant comparisons by computer disclose material types or volumes defined during any design stage that exceed those in the contract design material budget, budgeted man-hours increase accordingly and schedules have to be confirmed or adjusted. In order to maintain the validity of the material/man-hour corporate data, certain material management techniques are required.

Since they influence material/man-hour relationships, certain U.S. Navy purchasing activities, and material suppliers including those for Centrally Provided Material (CFM) are also de facto parts of a yard’s manufacturing system. In other words both material and production responsibilities are operational matters that should respond to the same ship modernization strategy. Further, the productivity of a manufacturing system is dependent upon knowing beforehand how material suppliers will perform as well as how their products will perform. Therefore operational considerations should be the primary basis for procurement regulations that shipyards must follow.

OpNav should, except for CPM and LLTM necessarily ordered before an implementing yard is designated, transfer all remaining material procurement responsibilities to implementing yards. This recommendation is peculiar to naval shipyards because they are required to employ purchasing activities outside of their commands for a significant part of their material procurement activities.

NavSea should work to remove any restrictions that may exist that prevent shipyards from initially ordering certain materials from diagrammatics, and from limiting the number of eligible bidders for productivity reasons. Large amounts of corporate data are essential for a modern manufacturing system. Regarding each product, this includes design details, approval status, quality, accuracy, ILS, prices, scheduled delivery record, and guarantee service record. Attempting to build the needed file of corporate data without limiting the number of prospective bidders for each item to no more than three, is simply impractical.

NavSea should require naval shipyards, and should recommend to private shipyards, that they employ the allocated stock (AS) material management concept.

NavSea should require naval shipyards, and should recommend to private shipyards, that they relate materials to man-hours.

NavSea should require naval shipyards, and should recommend to private shipyards, that they employ a computer to constantly compare materials being defined in later design stages to material budgets developed during contract design.

5.6 GENERAL

NavSea, as well as all those involved in the construction, modernization, overhaul and repair of naval ships, have a critical need to reexamine the way in which information, people, material and work are organized. Although the benefits of exploiting zone technology in production work are generally recognized, the rest of the manufacturing system has not been evaluated and altered to suit this approach. In general, most participants in the manufacturing system continue to employ system-by-system thinking for all preparations leading to production. Just before production starts, attempts are then made to reorganize information to utilize zone technology in production. Logically, one strategy is employed until production work is to start, and then a switch to a completely different one is made. This situation is the result of a manufacturing system that has evolved over many years.

This publication sets forth the premise that all parts of the ship modernization, overhaul and repair process should be recognized as being part of one manufacturing system. Thus the activities of planning yards are a critical part of the manufacturing system. Further, specific guidance for how planning yards should go about preparing ShipAlt information in order to facilitate implementation of zone logic is provided. OpNav and NavSea should review, evaluate and act upon these recommendations as a means of improving it’s ability to manage the construction, modernization, overhaul and repair of the naval fleet. As a practical matter, NavSea should revise and update the FMP Manual to reflect the goal of supporting and encouraging the productivity gains that can be achieved by employing zone logic in ship repair, overhaul and modernization programs. Suggestions for many of the revisions are provided in Part 3 of this report.

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